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Edited by

The Agricultural Adviser to the Government of India

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ORIGINAL ARTICLES

THE IMPERIAL MYCOLOGICAL CONFERENCE.*

BY

F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.,

Offg. Imperial Economic Botanist.

The First Conference of Empire Mycologists was held in the Imperial College of Science, London, during July 1924 and was largely attended by Mycologists from all parts of the Empire.

The conference was opened on 2nd July by Earl Buxton who in his opening address drew attention to the fact that for the progress of the tropical Dependencies of the Empire the fight against diseases of plants is scarcely less important than that against human diseases, while in the Dominions there was abundant evidence that the importance of the subject was more vividly realized than at home owing to the magnitude of their agricultural interests. The meeting then proceeded to discuss the *organization and activities of the Bureau of Mycology.* This subject was referred to a special committee of the conference. The committee examined and approved of a scheme for increasing the staff of the bureau and, as this scheme involved an increased expenditure of £1,500, recommended that an appeal should be made to the Governments of the Dominions, India, the Sudan, and the Colonies and Protectorates to provide the sum required. The recommendations of the committee were unanimously accepted by the conference.

At the second session the subject before the meeting was the *co-ordination of the investigation of fungicides.* Mr. Tattersfield (Rothamsted) in opening the discussion said that present explanations of fungicidal action were inadequate. The correlation of chemical constitution with toxicity was difficult and the best method of ascertaining this correlation would be to determine the toxic effect of certain compounds and then to see what changes in this toxicity were brought about by the introduction of new groups into the molecule. The toxic action of substances on fungi might best be studied in the vapour phase and the methods employed by

* The present account has been compiled from the official minutes of the conference which the writer attended as a representative for India.

Schafer might well be followed in fungicidal work. The liquid phase was complicated by such phenomena as absorption, wetting and adhesiveness—a substance might be highly toxic to an insect in the vapour phase but quite innocuous as a liquid. The methods to be adopted in any investigation should be carefully scrutinized in view of the variant factors such as temperature, age, acidity and the like, which might be introduced. Comparisons were easier if a 50 per cent. death point were aimed at, a fact which was demonstrated by graphs. Dr. Brierley (Rothamsted) spoke of the empirical nature of the work done on fungicides and urged the necessity for the standardization of the physical conditions of experiment, and of the organism as far as possible. Mr. Dowson mentioned his experience in East Africa in spraying against coffee leaf disease (*Hemileia vastatrix*). Owing to the accidental failure of the supply of lime, Bordeaux mixture was prepared with calcium carbide.* A fluid containing a black precipitate which did not settle was obtained, and this fluid gave a very adhesive and efficient spray deposit. After some further discussion it was decided that the Governing Body of the Imperial Bureau of Mycology be moved to appoint a sub-committee to deal with this subject.

Dr. Butler then opened the discussion on *plant disease surveys in the British Empire.* He said that in new outbreaks of disease it was most important to ascertain whether the parasite was a new introduction or not, as in the latter case the virulence of the epidemic was likely to be due to temporary circumstances and might be expected to pass when conditions became normal. The outbreak of *Diplodia Corchori* amongst jute in India was a striking example of this kind and reference was also made to the present epidemic of wither-tip of limes in Dominica. The powers of dissemination of parasites can often be ascertained from disease surveys and such information was of the greatest assistance in framing schedules for plant quarantine. Mr. Cotton (Kew) described the history of the survey of England and Wales and emphasized its importance in estimating losses from disease in legislating and in replying to queries from foreign countries. Dr. Shaw (India) stated that in 1922 a list of all the specimens in the Pusa Herbarium was published. A smut disease of mustard had appeared in India and it was very useful to them to be informed by the Imperial Bureau of Mycology that the disease had only previously been recorded from Denmark. Recently in India the schedule of prohibited plant imports had been revised, particularly in respect of Fiji disease of sugarcane, and it became of the utmost importance to know accurately the present distribution of this disease.

The first subject before the meeting at the third session was *the standardization of popular and scientific nomenclature in plant pathology.* Mr. Cunningham (New Zealand) in opening the discussion said that diseases must have popular names and confusion must result if these were not standardized. There was also some

* Calcium carbide 12 oz., copper sulphate 2 lb., and water 50 gallons.

considerable divergence of usage in scientific nomenclature and, until some standard basis for the distinguishing of species from one another was adopted, there was bound to be constant difficulty. He held the view that species should only be separable on morphological grounds. Mr. Cotton stated that the Pathological Committee of the British Mycological Society had undertaken the task of standardizing the common names of diseases in England and Wales. The most important principles were that the name adopted should be one in common use and should as far as possible describe the disease. Further discussion showed that the conference felt that there would be considerable difficulty in inducing the present generation of farmers to adopt standard names for diseases of crops.

The next subject was *the encouragement of industrial enterprise in the investigation of plant diseases*. Mr. Tunstall (Indian Tea Association) described the history of the scientific department of the Indian Tea Association, which, except for a small Government grant, was supported entirely by the tea industry. Dr. Butler stated that in his tour round the world he had been much impressed by the work being done by private enterprise. The Hawaiian Sugar Station cost £40,000 a year, but the growers were well satisfied with the results and the control of sugarcane diseases in Hawaii was scarcely equalled elsewhere, except, perhaps, by the Colonial Sugar Refining Co., which operated in Fiji, New South Wales and Queensland, and maintained a highly competent scientific staff. Colonel French (Empire Cotton Growers Corporation) stated that the funds of his Corporation were being utilized : (1) to send students to the Colonies to grow cotton ; (2) to encourage research by grants to research institutes and schools of agriculture ; (3) to send out experts to assist local departments of agriculture. The discussion terminated with the consideration of a proposal from the Government of Zanzibar that phytopathological officers might be trained to deal with both insects and fungi. A very definite opinion was unanimously expressed by the conference that such a course was unadvisable.

At the fourth session Dr. Doidge (South Africa) opened the discussion on *diseases of tropical plantation crops* with an account of the campaign against citrus canker (*Pseudomonas citri*) in South Africa. The disease was first noticed in 1908 and spread with amazing rapidity. The condition of affairs indicated that the only course to prevent the ruin of the citrus industry was to attempt the eradication of the disease by the destruction of all infected trees. The cost of the campaign to date had been £117,000 but it was now over two years since the last case was seen, and although the organism was known to be capable of living for a long time, the present position gave grounds for hoping that the disease had been exterminated. The next wet season would be decisive. Dr. Butler pointed out that if the ultimate result of these operations bore out the present hopes this would be thought be the first case of the total eradication of a disease.

Mr. Massey (Sudan) then gave an account of the diseases of cotton in the Sudan. The present outbreak of angular leafspot (*Bacterium malvacearum*) was described. The organism was readily isolated and inoculations proved its pathogenicity. It

was always accompanied by a yellow coccus which, however, was not pathogenic. The disease appeared immediately after germination in the seed-beds and the effect of humidity and temperature on its course was discussed, detailed data being presented to illustrate this effect. With regard to the question of control, it could be definitely said that the disease was carried over on the seed and the problem was one of seed disinfection. Disinfectants gave healthy plants but subsequent infection occurred, contact being sufficient to bring this about. The organism was unable to survive in the soil and was very susceptible to heat and light in the laboratory. Manure had no effect on the disease. Other allied plants in the Sudan did not become infected, though he had recently heard of a case of the sort in America. Several disinfectants had been tried, including uspulin, mercuric chloride, " sporocide," lysol, and Jeyes fluid. There was less fuzz on Egyptian cotton seed than on American and, hence, treatment with concentrated sulphuric acid was unnecessary. Lysol and the cresol disinfectants with resin soap gave more efficient wetting and in the present year the whole of the seed of the cotton crop was being disinfected with cresol disinfectants. The ideal treatment would deal with the pink bollworm, simultaneously with the angular leafspot organism and the recent work of disinfection of cotton seed by heating to 100° C. *in vacuo* might prove useful. Other diseases of cotton in the Sudan were briefly described, including an obscure disease, which is suspected to be due to *Rhizoctonia.*

Mr. Britton-Jones (formerly Ministry of Agriculture, Egypt) spoke of a root rot caused by a species of *Rhizoctonia* identical with the fungus hitherto called *Sclerotium bataticola* ; this disease and wilt disease both caused a certain amount of loss in Egypt. Dr. Shaw mentioned that researches now being carried out in India by Mr. Dastur indicate that wilted plants contain a higher proportion of aluminium than healthy plants and point to the toxic effect of aluminium as the primary cause of cotton wilt, fungi being possibly secondary agents. Mr. Summers (Shirley Institute) brought forward the subject of the mildewing of cotton fabrics, one which he stated was of vital importance to the cotton industry. The fungi causing these troubles seemed to be usually tropical moulds and the importance to cotton growers of growing clean cotton was emphasized, as in future the cotton spinners would not be inclined to buy cotton which had a reputation of being contaminated. Any fungus which had the power of lowering the p^H value had the power of spotting fabrics, while fungi which raised the p^H did not produce such striking symptoms but had a tendering action. Disinfection with ammonium silicofluoride and steeping with formalin had been tried.

Prof. Ashby (Trinidad) gave an account of the " Panama " disease of bananas. A toxin produced by the fungus (*Fusarium cubense*) probably played a large part in causing the characteristic symptoms of the disease. The spread of the disease was chiefly by the planting of infected rhizomes ; the organism could persist in the soil for at least ten years. The disease had been kept under control in Jamaica but the real solution of the problem was the discovery of an immune variety.

Mr. Bunting (Gold Coast) spoke of the diseases of cacao in the Gold Coast. Of these, one of the most important was caused by a new fungus, *Trachysphæra fructigena*. Other diseases were "collar crack" (*Armillaria mellea*) and the common parasite *Phytophthora faberi*.

The conference then proceeded to discuss the *influence of soil conditions on plant diseases*. Mr. Nowell (Trinidad) in opening the discussion expressed the view that many of the diseases of plants were due primarily to bad soil conditions and that the fungus was only parasitic when these conditions rendered the host susceptible. Diseases of this nature could be divided into two groups : (*a*) root diseases and (*b*) debility or poverty diseases. Root diseases might be occasioned by over-richness in the soil ; in the central portions of Dominica limes were grown in pockets of exceptionally rich soil, and in these places the lime is particularly susceptible to root disease associated with *Rosellinia*. On the other hand, rich soil might induce resistance in certain instances. Thus the cultivation of the Bourbon cane was rendered impossible throughout most of the West Indies by *Colletotrichum falcatum*, but in certain areas of rich soil in Trinidad this variety was still cultivated. Red ring, a nematode disease of the coconut, was mentioned as a type of disease apparently uninfluenced by soil conditions. With regard to debility diseases, these were largely occasioned by poverty of the soil. The root rot of sugarcane has been attributed to various organisms such as *Marasmius*, *Rhizoctonia*, *Odontia* and *Pythium*, but the speaker thought it was really due to failure to provide the cane with conditions suitable for the growth, the habitual presence of fungi being a consequence of a primary weakness in the plant. Poverty of soil was one of the causes of this weakness, and by good manuring the disease could often be completely overcome. Other unsuitable soil conditions could induce the disease ; thus, by applying ammonium sulphate in excessive quantity so that the soil becomes acid, an outbreak of *Marasmius sacchari* was usually induced. Potash deficiency in cotton leads to a disease known as yellow leaf blight, the leaves showing a peculiar yellowing and later becoming attacked by the weakly parasitic fungi, *Alternaria*, *Macrosporium* and *Cercospora*. Chlorosis of sugarcane occurred in patches of soil containing excessive amounts of saltpetre. "Blight" of sugarcane was really due to a soil factor, although insect attack was the immediately exciting cause.

Mr. Tunstall said that many of the diseases of tea could be controlled by soil treatment and cultivation. Brown blight (*Glomerella cingulata*), grey blight (*Pestalozzia Theæ*) and red rust (*Cephaleurus mycoidea*) were associated with a deficiency of potash. The disease caused by *Botryodiplodia theobromæ* could be cured by applications of potassium nitrate and examination of the plants after this treatment showed that the hyphæ of the fungus were absorbed by the host. Dr. Rayner pointed out the importance of mycorrhiza in relation to diseases which were influenced by soil conditions.

The subject before the conference at the last session was *the application of the results of mycological investigation*. Dr. Shaw opened the discussion from the point

of view of a tropical country with illiterate cultivators. He described the organization of the Agricultural Service in India and the methods adopted in the control of bud rot of palms, "black band" disease of jute, smut of sorghum, red rot of sugarcane and *Phytophthora* rot of areca palm. Dr. Murphy (Irish Free State) then dealt with the subject from the point of view of temperate countries with a more highly educated proletariat. He considered that there should be in phytopathology, as in medicine, a division of labour between the adviser, who is primarily concerned with the introduction of new methods of disease control, and the specialist, who investigates fresh problems. Any methods of control must be simple if it was to succeed in the hands of the agriculturist.

The scientific discussions now terminated and the following resolutions were unanimously adopted by the conference :—

1. That specimens of the diseases of plants in the different parts of the Empire be sent to the Bureau in sufficient quantity to enable sets of typical specimens to be prepared for distribution to institutions or individuals interested in the study of plant diseases throughout the Empire.

2. That lists of determinations of fungi sent in for naming should be published in leaflet form and distributed from time to time with the *Review*, the name of the sender and locality being indicated in each case.

3. That the Bureau should undertake at an early date the publication of a pamphlet containing the names and addresses of mycologists and plant pathologists in the British Empire, together with an indication of their special interests. This pamphlet should be brought up to date, say, every two years.

4. That copies of index cards dealing with the diseases of such crops as are indexed at the Bureau should be prepared on request and sold to the Government mycologists of contributing Dominions and Colonies at cost price.

5. That, in view of the benefits derived from an exchange of views between overseas mycologists, conferences similar to the present one should be held every five years.

6. That the proposal that the conference should consider the question of the interchange of investigators at certain centres throughout the Empire for periods such as six or twelve months be referred to the Imperial Botanical Conference.

7. That an annual report showing the contributions for the upkeep of the Bureau made by each contributing Government be circulated to the latter.

8. That the question of the formation of a body or sub-committee for the co-ordination of investigations of fungicides be brought before the Managing Committee of the Imperial Bureau of Mycology with the request that they take such steps as they deem fit.

9. That, while the training of mycologists should include a thorough grounding in the requisite sciences, mycologists should not be required to undertake the duties of entomologists in Government Departments of Agriculture.

10. That the proposals of the committee appointed by the conference to consider proposals for the future work of the Bureau and their cost be accepted as representing the requirements for the efficient carrying on of the work of the Bureau for the next five years, and that steps be taken to secure the annual income of £6,500 necessary to give effect to them.

11. That this conference is of the opinion that the financial portions of the report of the above committee be specially commended for the favourable consideration of the Managing Committee of the Bureau.

12. That this conference is of opinion that an urgent need exists for the provision of more adequate accommodation for the Bureau.

13. That this conference expresses its appreciation of the service rendered by the *Review of Applied Mycology* to all workers on the subject, especially those in overseas Dominions and Colonies, and is of the opinion that one of its most useful features is the length of the abstracts and would regret any curtailment in this respect.

14. That this conference of overseas mycologists desires to place on record its appreciation of the work which has been carried out by the Imperial Bureau of Mycology, and expresses the hope that this work will be extended when funds permit.

The members of the conference with few exceptions attended the Imperial Botanical Conference, which was held in the succeeding week, and at which considerable attention was given to economic mycology. The Ministry of Agriculture and Fisheries also issued invitations to all members of the Mycological Conference to attend a conference on the important question of legislation regulating the import of plants and plant products with a view to preventing the introduction of plant diseases. The discussions and excursions at these conferences covered a very wide field and materially assisted in making this first meeting of Empire mycologists a success. In addition to the formal meetings two excursions were arranged during the mycological conference, one to the Imperial Bureau of Mycology and one to the plant diseases exhibit in the Tropical Health Section of the British Empire Exhibition. At the latter a very striking and representative collection of plant diseases, to which mycological workers in India had largely contributed, was being exhibited to the public.

SOME FACTORS AFFECTING NITROGEN CHANGES IN BLACK COTTON SOIL.*

2. THE INFLUENCE OF MOISTURE CONTENT DURING THE RAINY SEASON ON THE AMMONIFYING AND NITRIFYING POWER OF BLACK COTTON SOIL.[1]

BY

F. J. PLYMEN

AND

D. V. BAL,

Department of Agriculture, Central Provinces and Berar.

Black cotton soil is primarily a *kharif* (monsoon) crop soil and the conditions controlling crop growth are largely the result of changes in the moisture content of the soil. A *kharif* crop such as cotton, *juar* (sorghum) or *til* (sesamum) has a relatively short growing season. The seed is put into the soil just when a long dry, hot period has been followed by a little rain. The seed germinates and the moist heat of the monsoon months produces or should produce rapid growth. It is not unusual, however, to find a field of *juar* water-logged and giving every appearance of nitrogen starvation, while the frequent response of cotton to a small dressing of nitrate shows that, under some circumstances, soluble nitrogen is in defect. The regular supply of soluble nitrogen to a growing *kharif* crop is, therefore, a matter of some importance, and it appears desirable to know how the natural supply of soluble nitrogen in the soil is controlled and affected by the intensity of the rainfall.

Most of the determinations made upon nitrates in Indian soils are concerned only with the supply of nitrate to cold weather (*rabi*) crops.[2]

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* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

[1] For No. 1 of this series entitled "The biological determination of the relative availability of different nitrogenous organic manures in black cotton soil" see *Agri. Jour. India*, 1919, Vol. XIV, p. 414.

[2] Leather, J. W. *Mem. Dept. Agri. India, Chem. Ser.*, Vol. II, pp. 63-140.
Clarke, G. *Agri. Jour. India*, 1922, Vol. XVII, pp. 463-475.

The observations thus recorded deal largely with nitrate accumulation, whereas the enquiry now under discussion was concerned with ammonification and nitrification in a soil carrying a *kharif* crop during the wet season.

Experimental.

The soil employed for these determinations was taken from a field always put under *kharif* crops such as cotton and *juar*. This soil is the common type of ordinary black cotton soil as found over large areas in the Central Provinces and Berar and many parts of the Deccan. The physical analysis of this soil has been given in a previous paper.[1] It is sufficient here to note that being a *kharif* field the soil from it is only moderately heavy. Samples of soil were taken to a depth of 8 inches every ten days commencing from the 5th of May to the 15th of December. The sampling of a clay soil during the monsoon is not an easy process. It is impossible to use a boring implement and go down into the sub-soil to any depth. For this reason only surface samples to 8 inches could be taken. This was carried out by inverting a metal box over the soil, pressing the box down to the required depth and then digging the whole out bodily. In these samples, determinations were made of moisture, nitrite and nitrate. The soils, as collected, were used for determining their ammonifying and nitrifying powers.

The sample was immediately brought to the laboratory and thoroughly mixed. A quantity of about 100 grm. was kept in a weighed basin and dried at a temperature of 100 to 105° C.

The amounts of nitrite and nitrate present in the soil of each sample were estimated by the usual Griess-Ilosvay and phenol-sulphonic acid methods respectively.

500 grm. soil from the well mixed sample were taken and oil-free sesamum cake supplying 60 mg. nitrogen per 100 grm. of the sample was mixed with it and the whole placed in a glass jar lightly covered. The jars were incubated at a temperature of 30—33° C. for a period of 8 weeks. Determinations of ammonia, nitrites and nitrates were made every 15 days, the ammonia being liberated by boiling with recently ignited magnesium oxide.

Data presented.

The amount of moisture and oxidized nitrogen in the soil at the time of sampling, and the amount of nitrogen ammonified and nitrified are given in Table I.

The figures show not only the easily available nitrogen present in the soil at the time the sample was taken but also the capacity of the soil, with water content as found in the field, to decompose any further nitrogenous matter which may be added

[1] *Agri. Jour. Ind.*, Sp. Ind. Sci. Con. No. 1919, p. 416.

TABLE I.

Showing the amount of moisture and oxidized nitrogen in the soil at the time of taking samples and the amount of nitrogen ammonified and nitrified (nitrified nitrogen includes both nitrites and nitrates).

Date	ORIGINAL SAMPLE				PER CENT. ADDED NITROGEN							
					AFTER 2 WEEKS		AFTER 4 WEEKS		AFTER 6 WEEKS		AFTER 8 WEEKS	
	No. of sample	Per cent. moisture	Nitrite N mg. per 100 grm. soil	Nitrate N mg. per 100 grm. soil	Ammonified	Nitrified	Ammonified	Nitrified	Ammonified	Nitrified	Ammonified	Nitrified
15th May . .	1	11·4	0·53	0·32	4·6	nil	2·8	nil	1·8	nil	0·9	nil
25th May . .	2	20·9	0·64	0·64	24·2	4·9	18·6	9·7	37·3	15·7	37·3	18·4
4th June . .	3	17·4	0·43	1·15	14·0	2·9	31·7	3·4	42·0	3·4	43·8	4·1
14th June .	4	23·8	nil	1·28	28·0	19·8	9·3	34·5	2·8	85·4	1·8	85·4
24th June .	5	19·4	traces	0·64	26·1	3·4	31·7	6·4	29·8	8·5	14·9	9·8
4th July . .	6	31·7	nil	traces	4·6	47·4	7·6	59·7	1·8	78·9	1·8	93·9
14th July . .	7	27·6	traces	0·51	18·6	42·8	7·4	56·3	1·8	81·4	1·8	96·0
25th July . .	8	32·3	nil	nil	18·6	54·0	3·7	81·3	2·8	76·0	0·9	85·4
4th August .	9	31·6	..	nil	18·6	53·9	4·6	64·0	2·8	72·6	1·8	81·13
14th August .	10	32·5	traces	traces	16·8	60·63	1·8	68·3	2·8	81·13	1·8	85·4
24th August .	11	38·9	nil	nil	3·73	35·35	9·3	43·25	4·66	59·76	..	59·76
3rd September .	12	36·4	nil	nil	9·30	41·70	1·86	76·85	..	76·85	1·86	81·13
14th September	13	43·7	nil	nil	4·66	21·96	..	32·89	..	34·16	..	32·02
24th September	14	37·0	traces	traces	13·06	45·35	..	54·92	..	64·0	..	76·80
3rd October .	15	33·7	traces	traces	..	44·08	..	77·0	..	76·85	..	72·58
13th October .	16	32·0	nil	nil	..	54·06	..	64·45	..	72·6	..	81·13
3rd November .	17	26·0	nil	nil	21·3	29·86	3·7	43·2	1·8	59·76	1·8	72·5
11th November .	18	22·0	..	..	32·6	2·1	28·0	4·26	..	..	28·0	7·4
24th November .	19	19·8	nil	nil	3·73	2·1	..	..	..	..	18·6	4·26
4th December .	20	17·1	nil	nil	1·86	nil	..	..	..		9·3	nil
15th December .	21	13·0	..	..	..	..	..	..	..	..	..	nil

to it. This capacity for decomposing nitrogenous matter may show itself almost immediately or it may not be of any great intensity even after a fairly prolonged period. For this reason the amount of ammonified and nitrified nitrogen formed in the soil was determined at intervals of two weeks.

The observations cover a complete period of the monsoon from before the first rain usually falls until a dry season is once more established. They also cover the

usual period of growth of a *kharif* crop from sowing time to harvest. The intensity of the rainfall and its distribution are shown in Fig. 1.

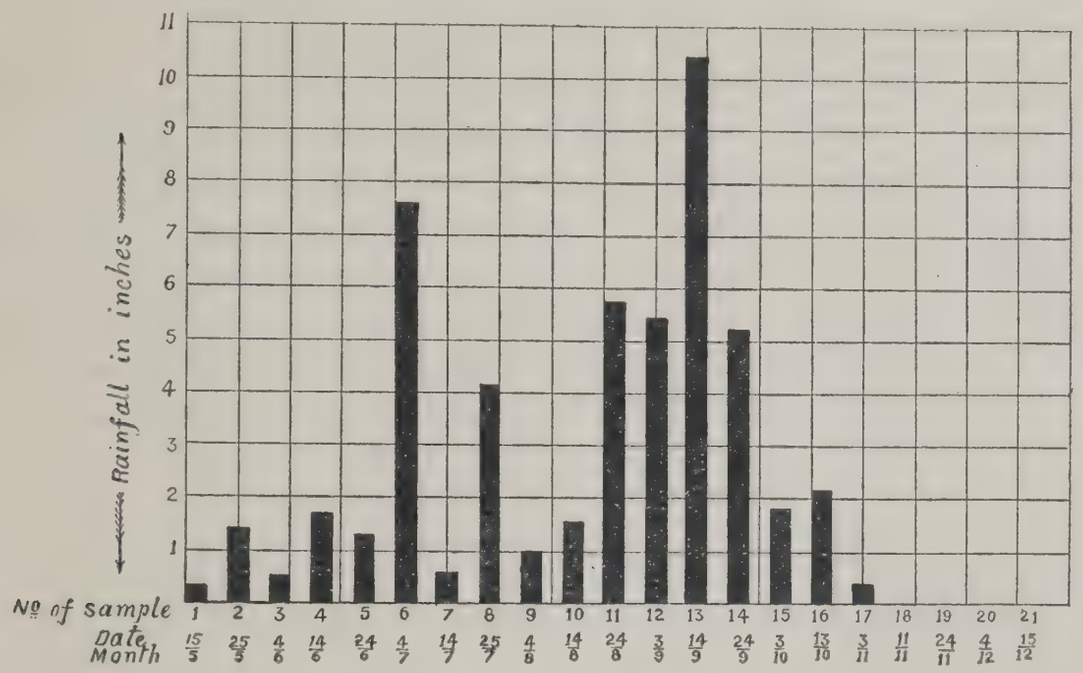

Fig. 1. Rainfall received during 10 days preceding the taking of sample.

Discussion of results.

It will be observed that, at the end of the hot weather just as the rainy season commences, the top layer of soil to a depth of 8 inches contained a little oxidized nitrogen both in the form of nitrite and nitrate. The disappearance of this oxidized nitrogen appears to have been almost simultaneous with the first heavy fall of rain, and it is interesting to observe that during the rest of the period over which the observations extended only slight traces of oxidized nitrogen were found again. This may have been due to the washing down of the nitrite and nitrate by the heavy rain and to the absorption of these substances by the growing crop. From the end of July to the early part of September the soil was in a wet condition containing at one time upwards of 42 per cent. of moisture. Even, however, when more moderate moisture conditions re-established themselves, the soil *in situ* showed no oxidized nitrogen.

The biological activity of the soil presents a number of interesting points, and in this connection it must be remembered that the activity of the soil in modifying the condition of nitrogenous compounds was determined on the soil as it was taken from the field and with the amount of moisture actually therein at the time. In its dry state in the month of May, the soil had no power to produce either ammonia or nitrified nitrog n, the formation of nitrified nitrogen being obviously controlled by the production of ammonified nitrogen. So long as the soil had a moisture content of less than about 23 per cent. it showed no great capacity for breaking down

organic nitrogenous compounds. With from about 24 to 36 per cent. of moisture this soil seems to attain its maximum biological activity, and this activity is of a fairly high order as from 50 to 60 per cent. of added organic nitrogen was oxidized within the short period of two weeks. These observations illustrate what the biological activity of a soil can be under suitable conditions of temperature and moisture content. It should be noted that at this time of year the shade temperature during the twenty-four hours fluctuates between 75° and 90° F.

With a moisture content of about 40 per cent. this soil deteriorates in nitrifying power, showing that the optimum moisture content for nitrification has been passed. With the natural advance of the season the soil gradually dries out and the biological activity of the soil diminishes with the reduction in water content.

Fig. 2 shows the variations in the water content and the total nitrate produced in the soil in a period of 8 weeks.

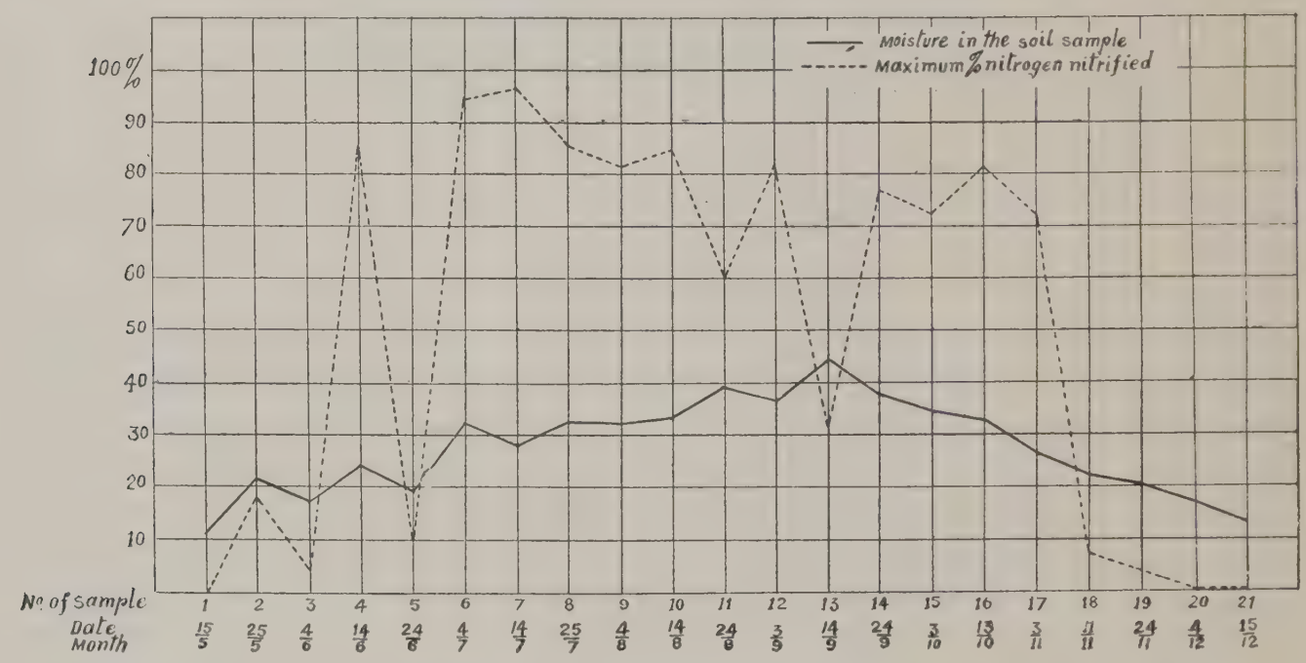

Fig 2. Variations in the moisture content of the soil at different periods and the maximum per cent. added nitrogen nitrified in eight weeks.

From these observations it is apparent that black cotton soil, under the climatic conditions described above, only shows any considerable bacteriological activity during four months of the year.

The importance of good drainage in a cotton field is also emphasized. Much of the land used for cotton production is often badly water-logged and retains a high proportion of water for a long period. This excess of water is seen, from the data now put forward, to result in checking the production of plant food and consequently in preventing plant growth. The value of a slight dressing of nitrate which has been found in practice to be very beneficial to cotton during the growing

season is doubtless due to its supplying readily available nitrogen at a critical time when the biological activities of the soil are temporarily suspended.

The authors would emphasize the necessity for distinguishing between nitrate accumulation in a soil and the nitrifying power of the soil. The figures given above show that it is possible to have a soil containing very little nitrified nitrogen in it and yet to possess a considerable capacity to produce that form of nitrogenous compound. The actual nitrified nitrogen accumulated in a soil depends upon a number of factors such as absorption of nitrate by the plant and movement of the soil water. The two factors, aeration of the soil and water supply, appear to be of the main importance in promoting nitrification in black cotton soil, the temperature of the soil being generally sufficiently high to encourage the process. Nitrification is a form of oxidation which is affected by the moisture conditions prevailing in the medium in which it occurs. The authors would, therefore, point out the desirability of always recording the water content of a soil upon which nitrification determinations are made.

The observations discussed above were made upon the soil as found in the field at regular intervals during the monsoon period. Further experiments, however, were conducted upon air-dry soil to which definite proportions of water had been added and worked into the soil by hand. The moisture content was fixed at a certain fraction of the maximum water capacity of the soil which is about 60 per cent. by weight as determined by Hilgard's method in a layer 1 cm. in depth.

From the figures given in Table II (Nos. 1–4) it will be seen that the results

TABLE II.

Showing nitrification in air-dry black cotton soil moistened to different degrees of saturation.

No.	Degree of saturation	Per cent. moisture	PER CENT. ADDED NITROGEN							
			After 2 weeks		After 4 weeks		After 6 weeks		After 8 weeks	
			Ammonified	Nitrified	Ammonified	Nitrified	Ammonified	Nitrified	Ammonified	Nitrified
1	$\frac{1}{4}$.	15	20·5	nil	27·1	nil	21·5	traces	..	traces
2	$\frac{1}{3}$.	20	28·0	nil	25·2	2·5	21·5	13·0	..	19·7
3	$\frac{3}{8}$.	22·5	31·7	1·5	27·1	8·2	7·5	64·0	..	68·3
4	$\frac{1}{2}$.	30	36·4	1·9	20·5	43·4	1·8	78·85	..	89·6
5*	$\frac{1}{2}$.	30	28·0	18·4	4·6	62·9	0·9	85·4	..	93·9

NOTE—Nitrified nitrogen includes both nitrite and nitrate nitrogen.
* The water was allowed to diffuse into the soil without mixing by hand.

obtained with artificially watered soils agree in general very closely with observations made on soils taken direct from the field. With a water content of 15 per cent. very little nitrification takes place. At 20 per cent. a slight action takes place within a period of 8 weeks. With a moisture percentage of from 22·5 to 30 per cent. nitrification is distinctly more vigorous. The chief point of difference between the artificially and naturally watered soils is that nitrification appears to be slow in starting in the former case even with a suitable soil moisture content. To suddenly give an air-dry soil a water content of 30 per cent. does not result in raising the soil's nitrifying capacity to the same extent as if the soil receives natural rainfall and gradually attains a 30 per cent. water content. In this connection figures for samples 6, 7, 8 and 9 of Table I and sample 4 of Table II can be compared. The amount of nitrification produced by these soils at the end of 8 weeks is approximately the same, but soils which have been receiving rain for some time can start their nitrifying action much quicker than air-dried soil brought at once to a 30 per cent. moisture content.

The question of tilth must also be considered. A heavy clay soil when mixed with water by hand assumes a lumpy form very different in tilth to that of a soil containing the same amount of water in the field. To determine the effect of the texture of the soil upon its nitrifying power an experiment was made in which 30 per cent. of water was allowed to diffuse into the soil without mixing by hand. The results obtained are shown in sample 5 of Table II. By comparing the figures for samples 4 and 5 in this Table it will be observed that the puddling effect produced by hand mixing delays the start of nitrification but that this delay is eventually made good.

Summary.

(1) The effect of the rainfall during the monsoon upon the oxidized nitrogen of black cotton soil has been studied.

(2) Figures are given showing the relation between the moisture content of the soil *in situ* and the nitrifying power of the soil.

(3) A moisture content of from 24 to 30 per cent. appears to enable black cotton soil to attain its maximum biological activity as regards nitrification.

(4) This activity is of a fairly high order as under the moisture conditions above stated and at the temperature prevailing during the monsoon months 50 to 60 per cent. of added organic nitrogen is oxidized in two weeks.

(5) Under the climatic conditions described in the paper, black cotton soil only shows any considerable bacteriological activity during the months from approximately mid-June to mid-October.

(6) Laboratory experiments in which definite quantities of water were mixed with air-dry black cotton soil agree with observations made on soil taken direct from the field.

(7) Nitrification in artificially watered soils previously air-dried is slower in starting than with soils receiving a natural rainfall, but the nitrifying efficiency after a period of 8 weeks is about the same.

(8) A heavy clay soil which had lost its texture showed at first a diminished nitrifying power when compared with the same soil in good condition.

RESEARCH WORK ON ANIMAL NUTRITION IN INDIA.*

BY

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It is a slogan of popular speech often heard that agriculture is the main occupation of the vast majority of the people of India, and the very life breath on which the economic prosperity of the country depends. It has been the staple industry of the country from time immemorial, and will, as far as one can judge, continue to be so, as India is an essentially agricultural country.

Very different is the story of the history of agricultural research, which is but in its early infancy, and whose chances of arriving at a healthy adolescence depend on the framing of liberal and systematic lines of enquiry, based upon the latest methods of scientific knowledge, and carried out by workers who can bring these methods to bear on the several branches of research into which the subject inevitably divides.

The *raison d'être* of research is primarily to increase the total food supply of the people both for their own personal consumption and for export in exchange for manufactured goods, and all branches of the subject which conduce to this end must be considered of equal importance. The particular branch of this research with which I at present propose to deal is that of animal nutrition. It needs no stretch of the imagination to realize that the cattle of India form the very foundation-stone so to speak of the country's agricultural activities, not only as draught animals, but as sources of food, and in particular, milk, and any research which aims at increasing the economic production both of work and of food must be of fundamental importance.

Although the history of agricultural research in general in India is a short one, it must be conceded that specialized research on animal nutrition is shorter still, in fact until quite recently, practically non-existent.

In 1921, at a meeting of agricultural chemists and bacteriologists held at Pusa, Mr. Warth introduced the subject of the food values of Indian foodstuffs, on which a general discussion followed and a resolution was passed that work should be pursued on general lines, and not be restricted to too narrow a field. Up to this

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* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

time no work, except isolated analyses, had been carried out in India, and this may mark the beginning of a systematic attempt to attack the problems of animal nutrition in India.

We have here a virgin field in which the only work done up to this time was some analytical investigations on foodstuffs mainly carried out by Dr. Leather. With the establishment of an Imperial Department for the carrying out of animal nutrition work, and with a keen interest displayed in one or two of the provinces, it would appear that the time has arrived for laying down a policy or programme of research and carrying it out in as systematic and comprehensive a manner as possible.

With this end then in view, I wish to point out what I consider are the basal lines along which the problem should be pursued, and to indicate the nature of the work which has already been started at Lyallpur during the last two years, and to plead for co-operation and collaboration between those who have made this work their particular study.

If we would glance for a moment at the institutions in such countries as England, America or Denmark, and note the intensity and nature of the research work carried on there, we shall gain some insight as to the possible lines of enquiry which might profitably be pursued in India. Every country has its own peculiarities and characteristics, and results and conclusions arrived at, say, in America on animal nutrition problems, need not necessarily hold good in India. The composition of a particular fodder common to both countries may be quite different in each, as may also be its nutritive value in the animal metabolism. Each country therefore, whilst adhering to general principles, must work out its own salvation in regard to details, a principle which holds good in research no less than in politics.

In a recent paper[1] on some digestibility trials carried out at Lyallpur in the winters of 1921 and 1922, I ventured to indicate three main lines of study on animal foodstuffs with their attendant problems although from each of these many others may branch out.

The first I call the crude routine analyses as carried out in the laboratory, and which, with a standardized process of procedure, should present no difficulty to the average laboratory worker. This in itself opens out many lines of enquiry. I have noted, for example, that the *bhusa* obtained from one year's harvest in the Punjab contains twice as much protein as *bhusa* from the previous year's harvest, and in framing any system of rations such divergencies in food values must be taken into consideration. There are undoubtedly many factors at present undefined which may influence the food value as revealed by chemical investigation, such as manuring, type of soil, water supply, climate, etc., to mention but a few, and it is highly necessary to accumulate all the data we can bearing on the variations of the nutrient materials in Indian foodstuffs.

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[1] *Mem. Dept. Agri. India, Chem. Ser.*, Vol. VII, No. 4, 1924.

The next line of enquiry I suggest follows logically from the first, and is the establishment of economic standard maintenance rations with systematically conducted digestion trials on a large number of suitable animals.

Food values as revealed by chemical analyses are not of necessity any criterion as to their actual value when fed to animals. Ingredients may be present in considerable quantities and yet not be capable of being fully utilized by the animal in the course of digestion. It is thus not so much the actual quantities of fats, carbohydrates, proteins, etc., which a feeding stuff may contain, but the quantities of these which the animal can actually utilize. We have in this connection to determine what are the most economical combinations of feeding materials to supply to our animals. An interesting illustration on this point was recently afforded me whilst working on the digestibility of fresh *shisham* (*Dalbergia sissoo*) leaves as a reserve fodder supply. Although chemical analysis revealed the leaves to be comparable with green oats in nutritive ingredients, yet the animals could not tolerate more than a very small daily ration, most likely due to the presence of some astringent principle which had a deleterious effect on the animal's digestive tract.

It is interesting to record that when the leaves were siloed, they preserved their main constituents practically unchanged, and the animals were able to be fed the material in considerable quantity. Dairy cows are also being fed on the siloed material, and the results will be published when ready.

Such trials as these are an absolutely necessary adjunct to ordinary chemical analysis for the determination of food values, and it is well to realize at the outset the comprehensive nature of work of this kind if properly carried out. A well-known American authority, Armsby, has recorded how, during some digestion trials carried out over several months, seven experts were continuously employed quite apart from the attendants looking after the general welfare of the animals. It is also necessary to emphasize the necessity for using a large number of suitable animals, and for the daily accurate record of all data such as body-weights, etc.

The third line of enquiry I suggest is perhaps most difficult of all, and involves the chemical and biological investigation of the proteins, etc., present in a foodstuff, their efficiency or otherwise in amino-acid content and the framing of suitable diets based on such knowledge, and also their values as determined by experiments on young growing animals. To give only one example. The low efficiency of maize as the sole source of protein to promote growth and well-being in young animals is well known, owing to its protein, Zein, being deficient in certain amino acids essential for growth, and a wide field of research opens up in this hitherto but little explored region of protein values.

There is one further line of enquiry which may be mentioned here, *viz.*, the subject of accessory food substances, which have come into great prominence in recent years. Certain well defined facts have been established, but the field in India is practically unexplored. We know that certain diseases such as beri-beri

and scurvy are due to the absence from the diet of minute quantities of certain substances as yet unisolated and of unknown chemical composition. Pellagra is another case in point, being essentially a disease of poverty, which, in its early stages, yields fairly readily to dietetic treatment. Indeed it is being emphasized by physicians that without dietary measures there is no effective treatment, and numerous cases are recorded in which the disease has promptly disappeared when milk, eggs and meats, together with a liberal amount of the leafy vegetables such as cabbage and lettuce, were included in the diet.

It is not too much to expect that research directed along these lines of dietetic investigation would bring to light further interesting and valuable facts bearing on the relationship of diet and disease.

In conclusion, no discussion on the subject of animal nutrition would be complete without reference to the important subject of milk-production. Milk is a complete food in itself, and the sole food for most animals at the time of birth, and there is no subject worthy of more sustained attention on the part of all branches of the community than that of producing an adequate supply of pure and wholesome milk for the people. The eugenist is at work on the production of improved breeds of cattle suitable to the country, the biochemist should be at work in collaboration with him in determining how to obtain the most economical yield of the greatest quantity of milk of the highest possible quality. There can be no doubt that the people generally do not realize the importance of milk and other dairy products in the diet. There is no substitute for milk, and its use should be distinctly increased instead of diminished, regardless of cost, whilst every possible means should be employed to reduce the cost of production. The necessity for the liberal use of milk and its products both in the diets of children and adults should be emphasized. The value of milk as a food cannot be estimated solely on the basis of its content of protein and energy; even when measured by this standard it compares most favourably with other foods, but it has a value as a protective food in improving the quality of the diet, which can be estimated only in terms of health and efficiency, and the greatest stress should be laid on the importance to the population of India of increasing the quantity and quality of its milk supply.

In all the lines of enquiry mentioned it is very necessary to keep the economic factor well in mind, and, whilst not overlooking the facts which may be of purely academic interest, concentrate attention on the goal to be aimed at, *viz.*, the application of results into actual practice.

I have but briefly suggested the more important lines on which research work on animal nutrition might profitably be pursued in India, keeping in mind the particular requirements of the country. Once a start has been made, many other specific problems will present themselves, and intensive and sustained effort cannot fail to produce valuable results and justify itself.

INTENSIVE NITRIFYING BED AS A MEANS OF PREVENTING NITROGEN LOSSES FROM CATTLE URINE.*

BY

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In a previous paper[1] on "Studies in methods to prevent nitrogen losses from dung and urine during storage," the writer has drawn attention to the fact that urine loses a large percentage of its nitrogen if kept under aerobic conditions; and in case it is necessary to preserve the urine without loss of nitrogen it has to be kept anaerobically. Further it was found that a layer of some oil spread over the urine brings about the conditions necessary to preserve the urine for a long time involving practically no loss of nitrogen. The layer of oil effectively prevents evaporation which is chiefly responsible for the loss of nitrogen in urine under aerobic conditions by causing formation and volatilization of ammonia.

Now, if the losses in nitrogen are, as stated, chiefly due to evaporation of ammonium carbonate formed from urea and other compounds in urine, it was considered that it would be possible to prevent such losses if the urine could be subjected to the rapid action of nitrifying bacteria which would convert it into nitrates before any loss takes place. There would be no difficulty in quickly nitrifying the urine if its nitrogen content were smaller, or what is the same thing, if it were diluted with water. But being concentrated in nitrogen so much water would be required for its dilution before nitrification took place, that it would prove quite uneconomical in handling. The obvious way of overcoming the difficulty is to develop the capacity of the nitrifying organisms to deal with a concentrated nitrogenous material like the urine. Muntz and Laine[2] have developed a method by means of which the process of nitrification is made sufficiently energetic to deal with larger concentration of ammonium salts in solution which is passed successively over several peat beds. The organisms in the last peat bed are able to tolerate the presence of a higher concentration of ammoniacal salts and nitrates by getting accustomed in gradually increasing quantities of these substances from first bed to the last. The necessity of such gradual increase of concentration will be apparent when it is known that the presence of high amounts of ammoniacal salts or nitrates in initial stages of nitrification stops the further development of the nitrifying organisms and paralyses their activity. Since urine contains organic nitrogen, it is not enough

* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

[1] Joshi, N. V. *Agri. Jour. India*, Vol. XVII, Pt. 4, July 1922.

[2] Muntz and Laine, *Annales de la Science Agronomique*, 3e Serie, 2, 1906.

for our purpose to develop organisms able to withstand higher concentration of ammoniacal salts alone, but it is necessary that nitrifying bacteria should continue their activity in the presence of higher amounts of organic nitrogen as well. In case this method proves successful urine will be required to pass over a bed of some material and ultimately recovered as a liquid containing nitrates in solution. Another way of accomplishing the same purpose would be to develop an intensive nitrifying capacity in some solid substratum which could be used as an absorbing material for urine. The principle involved in both cases is the same. It is the establishment of an intensive nitrifying bed.

In this paper it is proposed to give the results of laboratory studies undertaken with a view to find out whether it is possible to develop methods based on this principle.

In order to establish an intensive nitrifying bed the present writer started to get the cultures of nitrifying organisms by inoculating a small quantity of the local soil into 100 c.c. of Omelianski solution in a flask and containing 10 mg. of N as ammonium sulphate, and after the ammonium salt was nitrified (which takes place in nearly four to six weeks) a little of this solution was transferred to another flask containing the same solution. After a few transfers like this the organisms had become sufficiently active to serve as inoculating material for the nitrifying bed to be started. In the meanwhile study was made of the conditions for increasing the efficiency of the nitrifying organisms such as a suitable substratum, and the depth of the solution to be nitrified by carrying out some experiments under proper control. As a result of these, it was found that pumice or broken brick pieces serve as a good material for forming the bed (Table I) and that thin layers of nitrifying solutions

CHART I.

are better than deeper ones (Table II). The nitrifying solutions were, therefore,

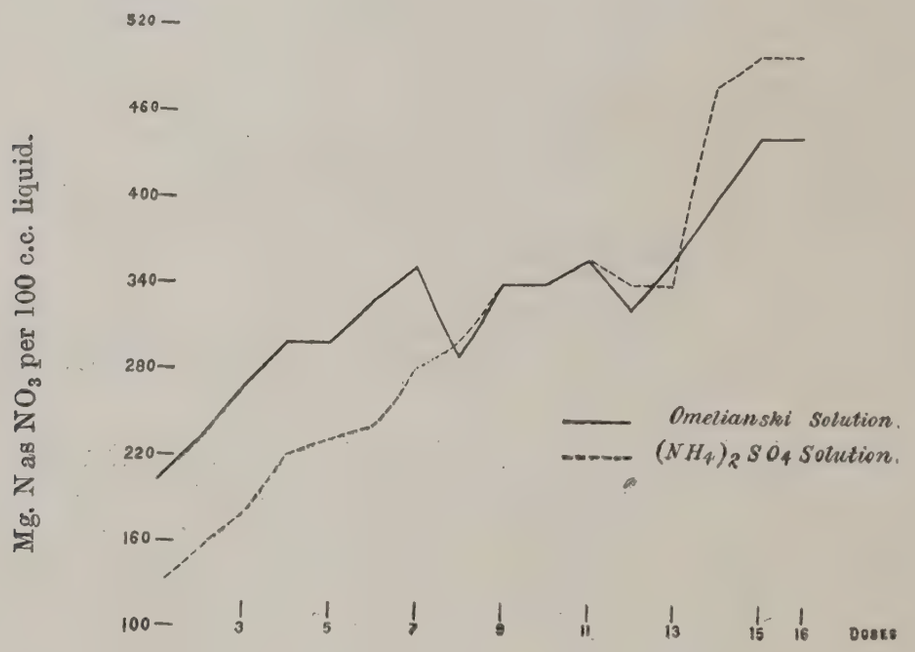

CHART II.

transferred to flasks containing these materials, the solution being kept in thin layers. After the nitrifying process was complete the solution was thrown out and a fresh solution was put in the same flask, the pumice or brick substrata being left undisturbed. When after a few changes of solution the cultures became active enough to nitrify the added Omelianski solution in one or two days instead of the four to six weeks required in the beginning, the dose of ammonium sulphate was gradually increased with each fresh addition and when the nitrifying bed was well established in this way its power of tolerating the nitrates already formed was tested by fresh additions of ammonium sulphate without removing the previously nitrified solution. The results of these experiments are set out in the curves (I and II) appended which go to show that the nitrifying organisms can acquire the property of tolerating a high concentration of nitrate nitrogen.

In the course of this investigation it was found that at certain intervals there is a loss of nitrogen which at first could not be accounted for. Attempts to find out whether there are any losses of nitrogen at a high concentration of nitrates were, therefore, made by keeping an account of the nitrogen added as ammonium sulphate and nitrogen recovered as nitrates. The following typical curve (III) shows, however, that these losses are only temporary, since, ultimately, the deficiency is made good by the appearance of the nitrogen as nitrates later on. We are unable to explain why this should occur, but we are led to suppose that the nitrates and the ammonium sulphate are assimilated or acted upon by the organisms

(it is immaterial whether nitrifiers or non-nitrifiers) and a third substance is pro-

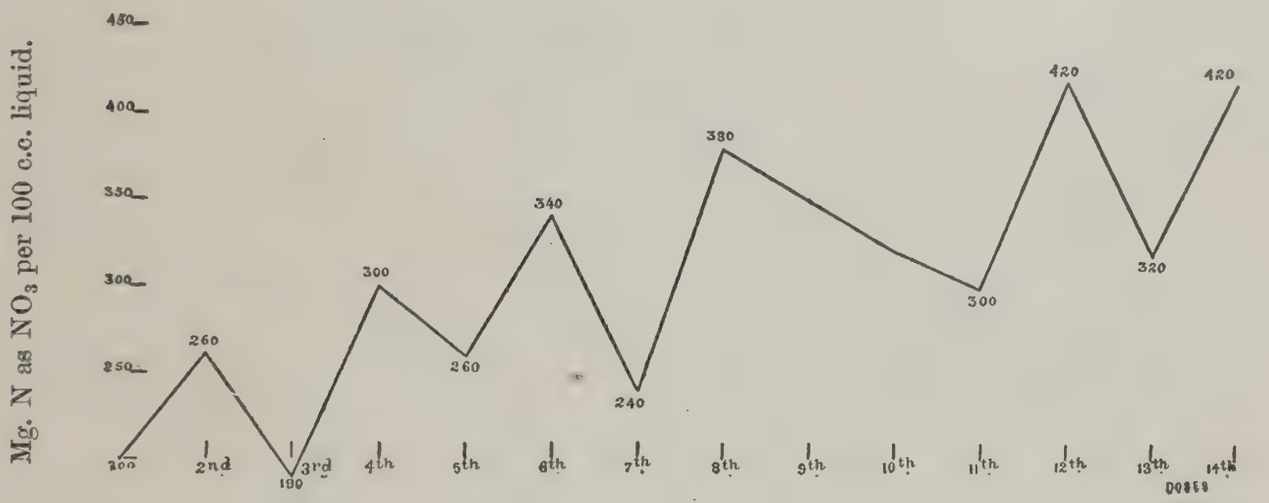

CHART III.

duced which does not give tests either of ammonia or nitrate.

TABLE I.

Nitrification experiments in Omelianski solution. 10 mg. nitrogen in 100 c. c.

Supporting materials in flasks		NITROGEN IN MG. AFTER DAYS					
		3	6	10	14	16	34
Pumice	NO_2	0·3888	1·1016	2·754	2·4	4·860	..
	NO_3	1·0	1·25	1·25	1·375	1·375	6·5
Brick	NO_2	0·7775	2·43	4·212	nil	0·405	..
	NO	1·0	1·75	2·25	12·5	11·87	10·5

The same continued after adding 20 mg. nitrogen in the form of 100 c.c. Omelianski solution to both the bottles (after taking out the liquid already present therein).

Supporting materials in flasks		NITROGEN IN MG. AFTER DAYS				
		3	6	10	14	18
Pumice	NO_2	0·2592	0·9072	0·0648	0·7128	nil
	NO_3	3·0	5·0	7·0	12·0	18·0
Brick	NO_2	0·486	3·24	0·729	0·648	nil
	NO	1·75	3·0	7·0	16·0	18·75

TABLE II.

Nitrification experiments in Omelianski solution. 10 mg. nitrogen in 100 c.c.

Treatment	Mg. nitrogen recovered as nitrate after days			
	3	7	14	21
Depth of layer—				
2 inches . . .	0·750	1·37	7·8	11·70
4 inches . . .	0·750	0·86	3·25	11·70
6 inches . . .	0·624	0·625	2·6	11·70

Restarted after further addition of 40 mg. nitrate as ammonium sulphate per 100 c.c.

Treatment	Mg. nitrogen recovered as nitrate after days				
	3	7	10	14	29
Depth of layer—					
2 inches . .	NO_3 4·0	27·0	30·0	28·0	28·0
4 inches . .	NO_3 7·5	28·0	34·0	32·0	35·0
6 inches . .	NO_3 5·0	12·0	16·0	22·0	27·0

Restarted after further addition of 40 mg. nitrate as ammonium sulphate per 100 c.c.

Treatment	Mg. nitrogen recovered as nitrate after days				
	3	7	10	14	16
Depth of layer—					
2 inches . .	10·0	40·0	40·0	40·0	44·0
4 inches . .	13·0	27·0	31·0	31·0	41·0
6 inches . .	9·0	22·0	30·0	30·0	39·0

In connection with this we may add that this phenomenon is well known to soil bacteriologists, because at certain intermediate stages, in the course of nitrification in soils or solutions, it is not possible to account for all the nitrogen that is intro-

duced for nitrification but which later on reappears as nitrate. This has often been observed in this laboratory. Beesley[1], working under Dr. Fowler's direction, observed the same in his experiments, and he explains it by assuming that even in the apparently simple oxidation of ammonia to nitrous acid there is an intermediate stage in which hydroxylamine is formed. Dr. Fowler[2] considers that nitrification is doubtless a process of progressive hydroxylation of ammonia.

Without attempting to discuss the subject at any length we venture to remark that although the results of the above experiments appear to lend support to Dr. Fowler's hypothesis, yet in view of the fact that no investigator has definitely proved that hydroxylamine is present in the nitrifying solutions, another way of explaining the phenomenon should not be overlooked. Thus it may be assumed, for instance, that the nitrifying organisms, in the first stage, assimilate nitrate or ammoniacal nitrogen for their own multiplication and growth, and convert it into proteid or amino nitrogen, and subsequently (*i.e.*, after their full growth) oxidize and excrete it in the form of nitrate. The alternative succession of these two stages would explain the temporary disappearance of the nitrogen and its subsequent reappearance as nitrate later on.

To turn to our experiments. Having succeeded with quick nitrification of ammonium sulphate, similar experiments were next repeated with other sources of nitrogen such as ammonium carbonate, urine and sodium nitrite. With ammonium carbonate there was no trouble, the nitrification proceeded in the same way as with ammonium sulphate.

In the case of urine (Tables III and IV) it may be pointed out that urine required

TABLE III.

Nitrification of urine replacing ammonium sulphate in Omelianski solution.

——	Initial nitrogen in mg.	Mg. nitrogen recovered as nitrates after 15 days
Dilution—		
1—200	4·7	2·0
1—100	9·41	1·0
1—50	18·82	nil
1—25	37·64	nil
1—12	72·28	nil

[1] *Jour. Chem. Soc. Trans.* 1914.
[2] Fowler, G. J. *Jour. Indian Inst. Science*, Vol. 3, Pt. VIII, 1920.

TABLE IV.

Nitrification of urine.

—	Mg. nitrogen added to 100 c.c. solution	Days taken to convert the same into nitrate
Dilution with water—		
1—10	104	19
	Further addition	
	104	16
	104	12

much dilution before it could be nitrified. At first it was difficult to get it nitrified in four weeks even when diluted to 50 times, and therefore it was necessary to dilute it to one and even two hundred times, but after the first addition of diluted urine and slowly increasing the concentration with each dose we have reached a stage when it requires to be diluted about ten times only. It is not possible to say whether the ultimate limit has been reached or whether the organisms could stand a still higher concentration.

Nitrites as a source of nitrogen were tried because, as already known, the process of nitrification of ammonium sulphate takes place in two stages, and ammoniacal nitrogen requires to be first converted into nitrite nitrogen before its final transformation into nitrate nitrogen ; and hence if these two stages are allowed to be carried on independently in different beds it was considered that they would work more efficiently without interfering with each other, as the efficiency of the later stage would not have to depend on the efficiency of the earlier one, and in this way they could perhaps be completed also earlier than usual. For this purpose four flasks of equal nitrifying efficiency (*i.e.*, nitrifying an equal quantity of ammonium sulphate in the same period of time) were divided into two batches. One batch received the nitrogen in the form of ammonium sulphate and the other nitrogen in the form of sodium nitrite. These were then compared for their nitrifying power. It was soon found, however, that the nitrite flask always lagged behind. We continued this experiment for over six months with the same unvarying result (Table V), from which it is concluded that the nitrate formers are able to effect the

TABLE V.

Nitrification experiments.

Number of days taken for 40 mg. nitrogen to form 100 c.c. nitrate bed.

Nitrogen added as ammonium sulphate	Nitrogen added as sodium nitrite
Days	Days
8	7
6	6
5	14
3	12
2	16
2	18
2	21

Maximum efficiency of nitrification of ammonium sulphate and sodium nitrite (in presence of optimum concentration of nitrate of each).

Maximum amount of nitrogen as ammonium sulphate converted into nitrates	Maximum amount of nitrogen as sodium nitrite converted into nitrates
40 mg. per day per 100 c.c.	14 mg. per day per 100 c.c.

nitrification more quickly if the nitrites are supplied in dilute doses as is brought about when they are formed from ammonium sulphate than by the nitrite forming organisms. This happens probably because the higher concentration of nitrite nitrogen is inhibitory to the organisms forming nitrates from nitrites. That even low concentrations are harmful to plant life is well known. Thus it had been observed in some experiments made in our laboratory at Pusa in 1914 that a concentration of 50 mg. nitrogen as potassium or sodium nitrite per 100 c.c. of the culture solution killed the maize seedlings within 1 to 3 days. While with the same concentration of nigtrogen as ammonium sulphate or potassium nitrate, the plants made good growth, showing that physiological dryness due to higher concentration of the salt (sodium nitrite) was probably not the cause of the

death of plants. In soil or sand cultures a concentration of nitrite nitrogen of 12 to 13 mg. per 100 grm. of soil was sufficient to kill the plants, showing that it was not the proportion of nitrites to the weight of soil that was responsible for the result but the proportion of nitrites dissolved in water. In other words, it was the concentration of nitrites dissolved in soil water that brought about the death of the plants in soil and sand cultures. It is rather interesting to observe that the nitrifying organisms which have the capacity to oxidize nitrites and so to say feed upon them should, however, work better when the nitrogen is supplied to them in the form of ammonium sulphate, a substance the nitrogen of which has to be converted into the nitrite form before being nitrified. The only reason why it should be so appears to be that when ammonium sulphate is the source of nitrogen, although it is rapidly converted into nitrites, there can never occur a concentration of nitrite nitrogen in the solution equal to that when nitrites act as the source of nitrogen, and that this initial higher concentration of nitrite nitrogen is inhibitory to nitrate formers, and hence the nitrate formers work much more efficiently when the nitrites are supplied to them in dilute doses. This view was found to be confirmed by the results of some further experiments with nitrate forming organisms in solutions containing varying concentrations of nitrites in separate flasks (Table VI).

TABLE VI.

Number of days taken for complete oxidation of 2 mg. nitrogen as nitrite.

Organisms	Contained in solution			
	100 c.c.	50 c.c.	20 c.c.	10 c.c.
No. 2	7	7	12	12
No. 3	8	10	12	12

This observation proved useful in another way inasmuch as colonies of organisms from the nitrifying organisms could be distinguished from those of the non-nitrifying ones in dilute nitrite solutions more quickly than in the stronger solutions formerly used.

These investigations have by now lasted for nearly two years, and as was naturally to be expected, we found that the process of nitrification goes on at laboratory temperatures more slowly in the cold season than in the hot weather. We get an idea of the efficiency of the process by determining the amount of nitrogen con-

verted into nitrates per cubic unit of space per day, and we find that in the cold season the efficiency is reduced on an average to 75 per cent. (Table VII). At the lowest temperatures recorded in the laboratory the efficiency went down to 60 per cent. of that observed in the warm period. There is thus a distinct seasonal variation due to temperature.

TABLE VII.

Nitrification experiments.

Treatment	MG. NITROGEN CONVERTED PER 100 C. C. PER DAY—AVERAGE OF 30 DAYS		NUMBER OF HOURS TAKEN TO CONVERT THE WHOLE INTO NITRATE—AVERAGE OF 30 DAYS	
	Hot season (30°C.)	Cold season (20°-25°C.)	Hot season (30°C.)	Cold season (20°-25°C.)
Dose of 40 mg. nitrogen as ammonium sulphate added successively after complete oxidation.	20	15	48	64

In our experiments we started with 50 c. c. of liquid and successively increased the capacity of the nitrifying bed to 100 and 250 c.c. and ultimately to 1 litre. We have been able to reach the same efficiency in each case, *i.e.*, the amount of nitrogen converted into nitrate has been found to be the same per cubic unit of space per day. As regards the amount of nitrogen that can be nitrified in this way continuously, we find that a litre solution containing 2 grm. of ammoniacal nitrogen can be completely oxidized by a nitrifying bed of a litre capacity in ten days. We propose to increase the cubic contents of the space occupied by the nitrifying bed but there is no reason to anticipate a lowering of the efficiency if we do so.

By this method of converting the nitrogen of the urine into nitrates we are enabled to get a liquid product which has an advantage in that it could be easily applied to the fields near by, the cost of labour for transporting being negligible. In case it is considered advisable to get *shora* or potassium nitrate, the solution has simply to be evaporated, the trouble and expense connected with the extraction of the nitre soil, etc., being eliminated.

While this method would be ideal under certain conditions, the liquid product may prove rather inconvenient to handle if it has to be carried a long distance and it may have to be absorbed by some solid material. The question then arises

that if some material has to be employed for absorbing the liquid product formed from the urine, why not begin by using it for absorbing urine. In this connection it occurred to the writer to devise what may be called an enriched nitrifying bed in the form of prepared or activated soil. It may be recalled that soil and straw were tried in our previous experiments as absorbing material but they proved ineffective on account of the fact that great losses of nitrogen occurred. It may be pointed out that these losses are chiefly due to rapid formation of ammonia in large amounts which is not as quickly nitrified as it is formed and hence it soon goes out of reach of the nitrifying organisms, a phenomenon well known to soil bacteriologists. We had met with this state of things in many of our earlier experiments when trying to find out the maximum capacity of soils to nitrify organic materials added to it. Table VIII illustrating two typical experiments in this direction

TABLE VIII.

Nitrification experiments with sarson cake in soil.

		1st week	2nd week	3rd week	4th week
Soil—extracted sarson cake @ 30 mg. nitrogen per 100 grm. soil.	NH_3	16·8	7·98	8·4	6·72
	NO_2	1·0886	6·9984	0·5832	0·03888
	NO_3	1·2	4·8	18·0	18·0
Soil—extracted sarson cake @ 120 mg. nitrogen per 100 grm. soil.	NH_3	47·54	42·12	42·84	27·3
	NO_2	nil	0·03888	nil	27·3
	NO_3	1·2	nil	Trace	0·9

Nitrification experiments with ammonium sulphate in soil.

		1st week	2nd week	3rd week	4th week
Soil—Am_2SO_4 @ 30 mg. nitrogen per 100 grm. soil.	NH_3	25·2	7·56	5·46	3·74
	NO_2	2·916	5·832	2·916	0·01944
	NO_3	Trace	4·8	12·0	31·2
Soil—Am_2SO_4 @ 120 mg. nitrogen per 100 grm. soil.	NH_3	91·98	83·56	68·88	34·86
	NO_2	0·02916	0·0486	0·0777	0·0388
	NO_3	Trace	Trace	0·9	0·9

is reproduced to show the course of decomposition with different amounts of nitrogen added to the soil for nitrification. Now this capacity of a soil to nitrify organic nitrogenous materials depends on many factors, chief of which we need consider are the number and efficiency of nitrifying organisms present in the soil. Looking upon the soil as a biological machine to turn out a certain product (in this case nitrates), our object is to improve the efficiency of this machine, which can best be achieved by increasing the number and physiological activity of the nitrifiers in the soil. We therefore began, as in the case of the liquid nitrifying bed, by giving small doses of nitrogenous materials within the capacity of the organisms already present in our soil (we may add parenthetically that practically any cultivated soil in any locality will do just as well); and after the nitrates were formed the soil was washed out so as to remove the nitrates and then dried and again used as a medium for the growth of the nitrifying organisms. If now the soil is divided into separate lots and different amounts of nitrogenous materials are added to each, it will be found that the capacity of the soil to nitrify is very much increased. In our experiments we tried only four times the quantity of nitrogen previously supplied and it was nitrified much quicker (Table IX). It is easy to see that by repeating

TABLE IX.

Nitrification experiment with soil in which nitrification had previously gone on for 4 weeks.

Treatment		1st week	2nd week	4th week
Soil previously nitrified and containing 18 mg. nitrate nitrogen initially.	NH_3	73·36	Not estimated	10·92
	NO_2	2·3328	0·3888	0·0388
	NO_3	21·6	43·2	72·0
Soil previously nitrified and containing no nitrite nitrogen initially.	NH_3	73·92	Not estimated	9·24
	NO_2	2·916	0·3499	0·0582
	NO	6·0	62·4	78·0

this process we will ultimately get a medium which will be able to nitrify higher and higher quantities of nitrogen. We have not yet determined the maximum efficiency that the soil will attain to in this way, but we have reached a limit where the activated soil nitrifies nearly sixteen times the nitrogen that it used to do in the beginning.

It might be gathered from what is written above that there is a possibility of the establishment of intensive nitrifying beds for the rapid conversion of the cattle urine into nitrates and saving its nitrogen from loss by evaporation, and that suitable

methods could be developed to carry this out in practice by using different materials as carriers of nitrifying bacteria. It is not possible, however, to give exact details of the methods, as the question is rather of wide interest and the needs of cultivators in different places are not alike, and hence those desirous of preventing the loss of nitrogen from the cattle urine by this process will have to make some preliminary trials to determine the size of their nitrifying bed according to the quantity of cattle urine at their disposal. It is presumed, however, that those wishing to undertake such trials, without previous experience, would find it useful to have a description of the practical methods depending on the principle of intensive nitrification in practice. A brief sketch of working the processes is, therefore, given here so as to enable each individual to make his trials, with such modification as may be necessary according to local requirements.

The Liquid Nitrifying Bed Method.

Taking the first method in which the final product is a liquid containing nitrates in solution, it may be pointed out that the chief thing necessary is to develop intensive beds for nitrifying the urine. The beds may be formed in some pits, preferably near the cattle shed so that the urine could be directly led into them. The pits are filled with some material like broken brick pieces or *kanker* which act as carriers of the nitrifying organisms and are useful in providing the aeration necessary for the rapid nitrification.

The next thing that is necessary is the introduction of the useful nitrifying bacteria into these beds before they can be used as nitrifying beds. There is no necessity to get special cultures of these. The purpose will be served by leading some urine diluted with water and adding some fertile soil into the pits. The urine will get slowly nitrified and this can be ascertained by the absence of the peculiar urine smell and the disappearance of ammonia in the liquid. The liquid can now be taken out of the pit and fresh urine, more concentrated than before, put in. This process will have to be repeated for some time, when the dilution of urine need only be about fifteen times or less. Now the bed may be taken to have established itself. The number and size of such pits to be used as nitrifying beds will no doubt depend on the quantity of urine available. The pits will have to be made impervious by cementing or by placing tiles at the bottom, but the walls need not be cemented because any urine that will seep through into the soil will be nitrified there and the soil could be extracted of its nitrate or used as manure. Instead of pits the process can be carried on in *ghailas* or earthenware jars also, thereby showing that the method is workable within very wide limits. The pits should receive the urine in rotation so that by the time the last is full the first should have completed the nitrification and be ready to receive another lot.

With nitrification proceeding at the average rate it will take 8 or 10 days to completely nitrify one gallon of urine (containing 1 per cent. nitrogen) in a nitri-

fying bed of $\frac{1}{7}$ cubic foot. Taking this as a basis, the number and size of pits may be determined according to the quantity of urine available. It has to be borne in mind, however, that sometimes the process lags behind, and the provision of extra space is necessary in order to meet any such untoward contingency. Making allowance for this, we may say that a rectangular pit of two cubic feet dimensions divided into 14 compartments will be able to deal with one gallon of urine per day. In this process the resulting product will be liquid and the contents of the pit will be nitrified within a short time. The pits will therefore require to be emptied every ten days or a fortnight.

The Activated Soil Method.

Many will for this reason prefer the second method of using the activated soil for the purpose of nitrifying the urine. To them we would recommend the following method which is capable of adaptations as may be necessitated by the quantity of urine to be absorbed and the space available for absorbing it. In this method the enrichment of the soil with nitrifying organisms should be done by adding to it some urine diluted with water in the beginning. In case of the Pusa soil the following proportions were found to be suitable to make the soil moist and yet friable : 3 parts of urine, 100 parts of soil and 12 parts of water. After four weeks, the nitrified soil should be washed out of its nitrate and the washed soil dried under shade and again used. This may now be treated with 12 parts of urine to 100 parts of soil with the necessary quantity of water to make it sufficiently moist and again allowed to nitrify. The process may be repeated if necessary by increasing the quantity of urine. After two or three such repetitions, the soil will generally be in a fit condition for directly absorbing urine with a high nitrogen content. When the soil is thus ready it may be filled in pits. The pits shall be so situated that urine from the cattle shed can be conducted into them by a channel. If the pit is of sufficiently large dimensions, the process of activating the soil may be carried on in the pit itself by adding urine and water to the soil in the pit in the proportions stated above. In this case although it may take a little longer time to activate the soil, the process of washing out the nitrates can be done away with and repeated additions of urine directly made as a measure of economy. When the pits are full of activated soil they should be marked out into 28 compartments by ridges of the soil, and urine should be added daily to each of these compartments by turns. By the time the last compartment is filled with urine, the first compartment will have completed its nitrification and will be ready to receive a second dose of urine. Similarly the other compartments will also be ready in succession. After six or eight such doses of urine, which will take 24 to 32 weeks, the soil in the pits will be ready for manuring, and can be taken out and the pit refilled with fresh soil. The activated soil contained in a pit of the dimensions of 6 feet long $\times$ 2 feet wide $\times$ 6 inches deep divided into 28 compartments will conveniently deal with a

daily output of one gallon of urine containing 1 per cent. nitrogen. The dimensions of the pit may be altered to suit one's convenience so long as the right proportions of cubic space and the nitrogen to be nitrified are observed. Thus the same cubic space may be divided into two or three pits of smaller size to enable one to conveniently handle the soil of each pit separately.

In presenting the above outline of the two methods the writer would like to take the opportunity to observe that the data on which the outlines of working the processes is based were obtained from a large number of experiments continuously carried out for over two years in the bacteriological laboratory at Pusa and may be taken as absolutely reliable so far as the experiments go ; yet the drawbacks which generally attend any application of the results of laboratory experiments to large scale trials will naturally present themselves in this case also, and the writer, although confident of the results obtained in the laboratory, cannot but expect that difficulties will arise in translating the results of his experiments into actual practice. The outline of the processes given above should not, therefore, be treated as an authoritative account of a well established practice but rather as a guide to critically examine a promising but as yet only a newly recommended process.

Before finishing we could just call attention to one other consideration. It is in fact an answer to the question as to what gain will accrue from spending so much labour on saving urine. If we consider for one moment the amount of nitrogen contained in cattle urine almost all of which is wasted at present we will get some idea as to the saving likely to be effected. The urine excreted by cattle is put down in text books from 10 to 40 pints per head per day, the quantity varying according to the age and size of the animals as well as the season and the diet given. Let us suppose that on an average 2 gallons of urine is excreted by one animal in 24 hours. The amount likely to be saved is therefore 1 gallon or 10 lb. during the time that the animals are kept in the cattle sheds. Urine of cows that we experimented with contained on an average 1 per cent. nitrogen. The nitrogen in the urine saved from one cow is therefore about 0·1 lb. per day, which means in one year 36·5 lb. of nitrogen per head of cattle. If all this nitrogen were converted into say potassium nitrate, we get 2·5 mds. of potassium nitrate by extracting it from the nitrified soil. Even if we are able to recover only 40 to 50 per cent. of this quantity because of the crudest method employed, it will mean 1 to $1\frac{1}{4}$ mds. of potassium nitrate or *shora* or an equivalent amount of nitrogen recovered from the urine. The cultivator is at present allowing this to go to waste. Is it not then worth his while to turn his attention to this problem and convert the cattle urine into some material which will prove useful to his crops or bring money into his pocket ?

It will thus be seen that the methods advocated here are not merely of academic interest ; though they may look tedious at first, they are none the less quite practicable. In this connection we may refer to two papers by Boullanger in *Annales*

de L'Institut Pasteur, Vols. 35 and 36. This author has used an elaborate apparatus, including iron tanks and pumps, for filtering and raising the liquid to be nitrified from tank to tank, and used ammoniacal salt solutions in his work. Working on a semi-industrial scale the author has shown that it pays to produce nitrates from the solution obtained after nitrification of ammoniacal salts in this biochemical process if the nitrification proceeds rapidly enough, *i.e.*, if the rate of nitrification is such that 75 litres of a solution containing 1·5 grm. ammoniacal nitrogen per litre are converted into nitrates by passing through a bed of peat 1 cubic metre in space in a day. This means that 0·75 litres of a solution containing 1·5 grm. of ammoniacal nitrogen per litre should be nitrified in a bed of peat of 1 litre capacity in 10 days for economically working it.

In our experiments we get in the cold season 1 litre of a solution containing 1·5 grm. of ammoniacal nitrogen per litre completely nitrified in 10 days in a bed of one litre capacity, which is 33 per cent. higher than that required for economically working the method according to Boullanger's figures. The amount of nitrogen converted into nitrates in the hot season is again 33 per cent. higher than that of the cold season. From this it will be easily seen that in our method for nitrification of urine the rate of nitrification considered as economic from an industrial point of view will be maintained without much difficulty. Further it may be pointed out that in our experiments we waited for the complete disappearance of ammonia before adding a fresh dose of ammonium salt. It is not, however, necessary in practice to wait for the disappearance of the final traces of ammoniacal nitrogen, and consequently in practical working of the process we may expect to realize a higher rate of nitrification than what we have given above.

We think, therefore, that the principle of the intensive nitrifying bed is very likely to succeed in practice if trials are made on a scale larger than what is practicable in the laboratory.

Summary.

Large losses of nitrogen occur when cattle urine is preserved under aerobic conditions. It was considered that it would be possible to prevent such losses if the urine could be passed over intensive nitrifying beds where it could be subjected to the rapid action of nitrifying bacteria which would convert it into nitrates before any loss takes place. Experiments were therefore undertaken to find out whether such intensive nitrifying beds could be established and whether urine would be nitrified without loss of nitrogen, and it has been found that there are two ways of accomplishing this in practice. In one the urine is passed over a nitrifying bed and ultimately recovered as a solution of nitrates. In the other method the urine is absorbed by means of a specially prepared or activated soil.

A general outline of working these processes is included in the paper to enable those interested in the subject to make their own trials.

In the first method, pumice or broken bricks serve as suitable substrata for the organisms in the nitrifying bed. The depth of layer of liquid to be nitrified possesses great influence over the nitrification process. Urine could not be nitrified directly without dilution in the nitrifying beds up till now. With the most active bed prepared so far urine requires to be diluted with ten times the quantity of water.

In the second method soil prepared by previously nitrifying some nitrogenous material in smaller quantities and washing out the nitrates is used for absorption of urine. If ordinary local soil is used for absorbing the urine directly without any such preparation large losses of nitrogen (approximately 70-80 per cent. of the original amount) occur. The object of preparing the soil is to activate the nitrifying organisms and thus make the soil capable of nitrifying the high quantities of nitrogen in the urine rapidly and thus prevent losses of nitrogen which would otherwise occur.

It is estimated that about 2·5 mds. of potassium nitrates, *i.e.*, pure *shora*, may be obtained from a single animal's urine (containing about 1 per cent. of nitrogen) if it were converted into potassium nitrate by this process of intensive nitrification, provided no loss of nitrogen took place during handling.

Even if the crudest method of handling alone is possible for any individual resulting only in 50 per cent. recovery of the nitrogen in urine as nitrate, and the nitrogen content of the urine of animals be half of what was found in the case of the dairy herd at Pusa, it is estimated that 1-1$\frac{1}{4}$ mds. of potassium nitrate or a manure containing an equivalent amount of nitrogen therein will be easily obtained per year if the urine of a pair of animals is regularly subjected to this process. It will be seen therefore that the urine of animals conserved in this way will go a long way to meet the manurial requirements of the cultivators.

INHERITANCE OF CERTAIN CHARACTERS IN *GOSSYPIUM*.*

BY

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Cotton Breeder in Sind.

THE genus *Gossypium* furnishes an unusual wealth of materials in the way of distinct varietal and specific types. Probably no other genus of crop plants contains so many domesticated species, to say nothing of endless varietal forms to be found in all cotton-growing countries.

The cotton plant has numerous specialized characters some of which are very important from the plant breeder's point of view. The breeder differentiates these important characters into two main groups, firstly those which tend to increase the intrinsic value of the crop, secondly those which help in keeping his strains or varieties pure. In order to breed suitable types with desirable characters the plant breeder must have an intimate knowledge of these characters, their mode of inheritance, and how they react to environment. In this paper we propose to describe the mode of inheritance of certain characters of practical significance to plant breeders and the cotton farmers at large.

1. INHERITANCE OF SEED FUZZINESS IN COTTON.

The mode of inheritance of the distribution of fuzz on the seed has been investigated in the past by Balls[1] in Egypt and McLendon[2] in the United States. The results obtained in the experiments about to be described do not seem to coincide with those of the earlier experiments and throw a new light on the subject.

Before describing our results it may be appropriate to make clear the vague use of the terms expressing the distribution of the fuzz on the seed. For convenience sake cotton seeds may be grouped according to the distribution of the fuzz on the seed-coat as follows :—

Group 1. Naked seeds. Seeds having absolutely smooth seed-coat as possessed by some American Uplands and a strain of Sea Island cotton.

Group 2. Partially fuzzy seeds. These are characteristic of all Egyptians and also some strains of Sea Island. In these seeds a portion of the seed-coat to a greater

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* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924. The experiments described in this paper were carried out at the Agricultural and Mechanical College, Texas, U. S. A.

[1] Balls, W. L. Some cytological aspects of cotton breeding. *A. B. A. An. Rep.* 1909.

[2] McLendon, C A. Mendelian inheritance in cotton hybrids. *Ga. Exp. Stn. Bull*, 99.

or less extent is uncovered and the rest is more or less fuzzy. Thus the Sea Island strains have almost smooth seeds which have small tufts of fuzz at both ends. The Mit-afifi variety of Egyptian cotton has a naked patch on the back of the seed and the remaining portion is very fuzzy. The Yuma variety of Arizona Egyptian cottons has most of the seed-coat smooth with little tufts of fuzz at two ends extending along the raphe. The Pima variety of American Egyptian cottons again has much more fuzz than the Yuma.

Group 3. Entirely fuzzy seed-coat. The American Upland cottons have mostly, with few exceptions, seeds which have fuzz distributed all over the seed-coat. The same is the case with Indian cottons. This group may for convenience be sub-divided into (*a*) woolly, (*b*) felted, (*c*) scanty fuzz, such that the dark coat of the seed can be seen through.

Behaviour of various kinds of seeds.

Naked seeds. Entirely naked seed as present in the Upland cotton variety called No Lint is completely dominant in the F_1 generation over fuzzy seed (all the three sub-divisions) of some of the American Upland cottons (Plate I, fig. 1).

In the F_2 generation the segregation is in accordance with the simple Mendelian inheritance as may be seen from the following table :—

Table I.

F_2 segregation of naked versus entirely fuzzy seed in cotton.

Serial No.	Cross	No. of individuals			Remarks
		Naked	Entirely fuzzy	Total	
1	Durango × No Lint .	30	7	37	Durango parent has a woolly seed.
2	No Lint × Lonestar .	14	5	19	Lonestar parent has a woolly seed.
3	No Lint × Texas Rust .	41	14	55	Texas Rust parent has a woolly seed.
4	Black Seed × No Lint .	16	6	22	Black Seed parent has a scanty fuzz.
5	Acala × No Lint . .	53	18	71	Acala parent has a woolly seed.
6	Acala × No Lint . .	49	16	65	Acala parent has woolly seed.
	Observed totals . .	203	66	269	
	Calculated on simple Mendelian inheritance.	201·75	67·25	269	

The ratios obtained clearly show that this pair of characters is determined by a single pair of factors and expectations were fulfilled in the F_2 generation.

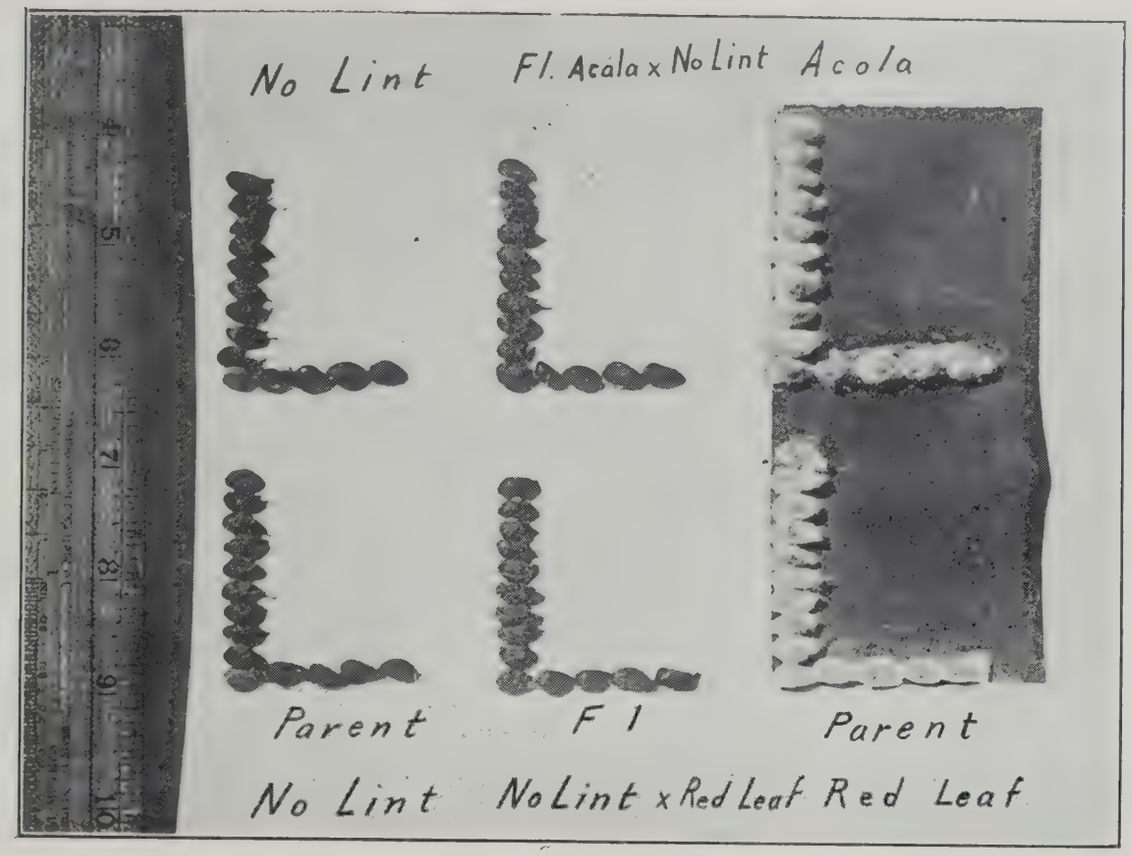

FIG. 1. *Top (from left)*. Naked parent, F_1 hybrid, Fuzzy (woolly) parent.
Bottom (from left). Naked parent, F_1 hybrid, Fuzzy (felted) parent.

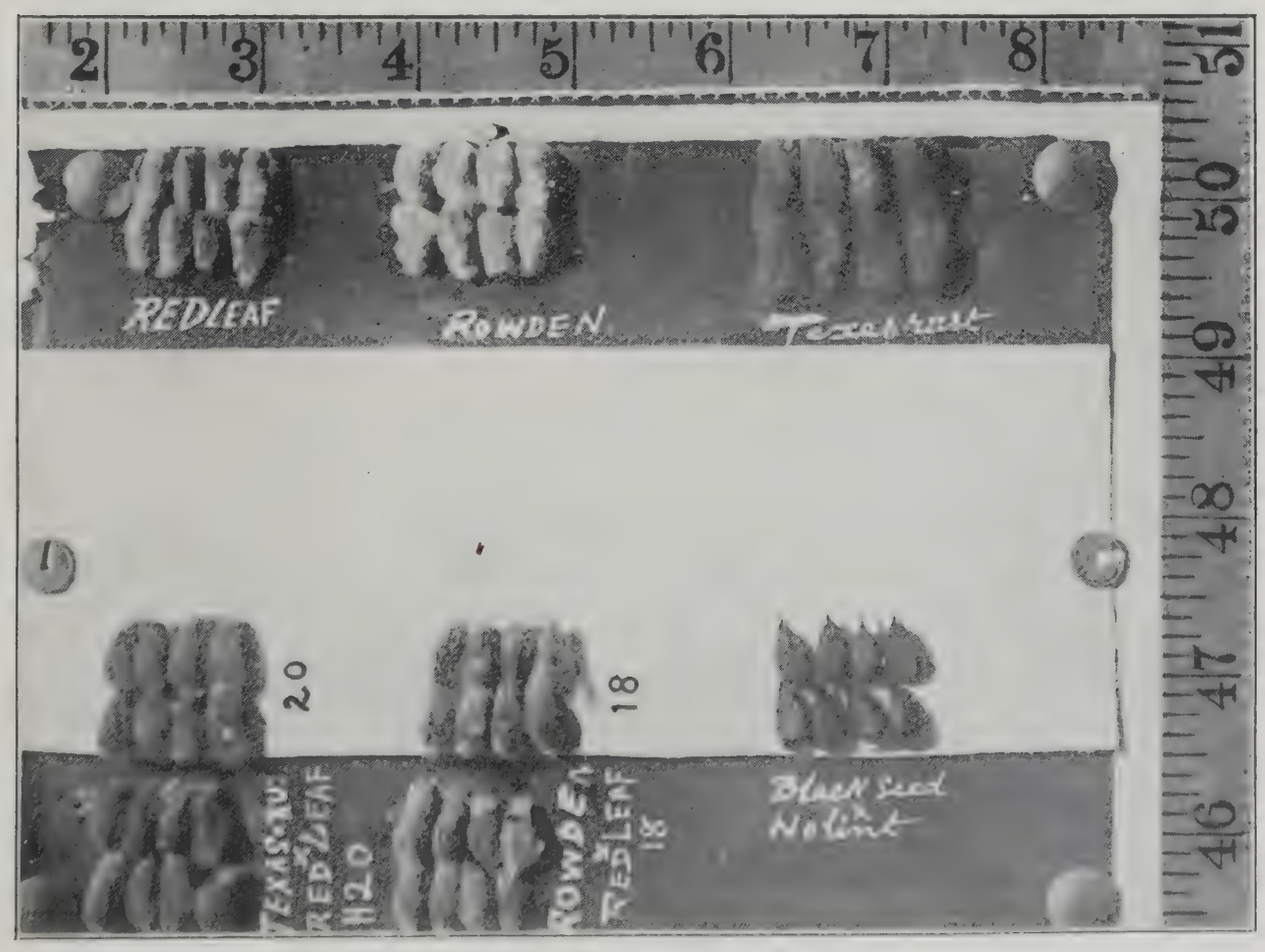

FIG. 2. *Top (from left)*. Felted, woolly and woolly parents.
Bottom (from left). F_1 Woolly × felted, Woolly × felted, Naked × scanty fuzz.

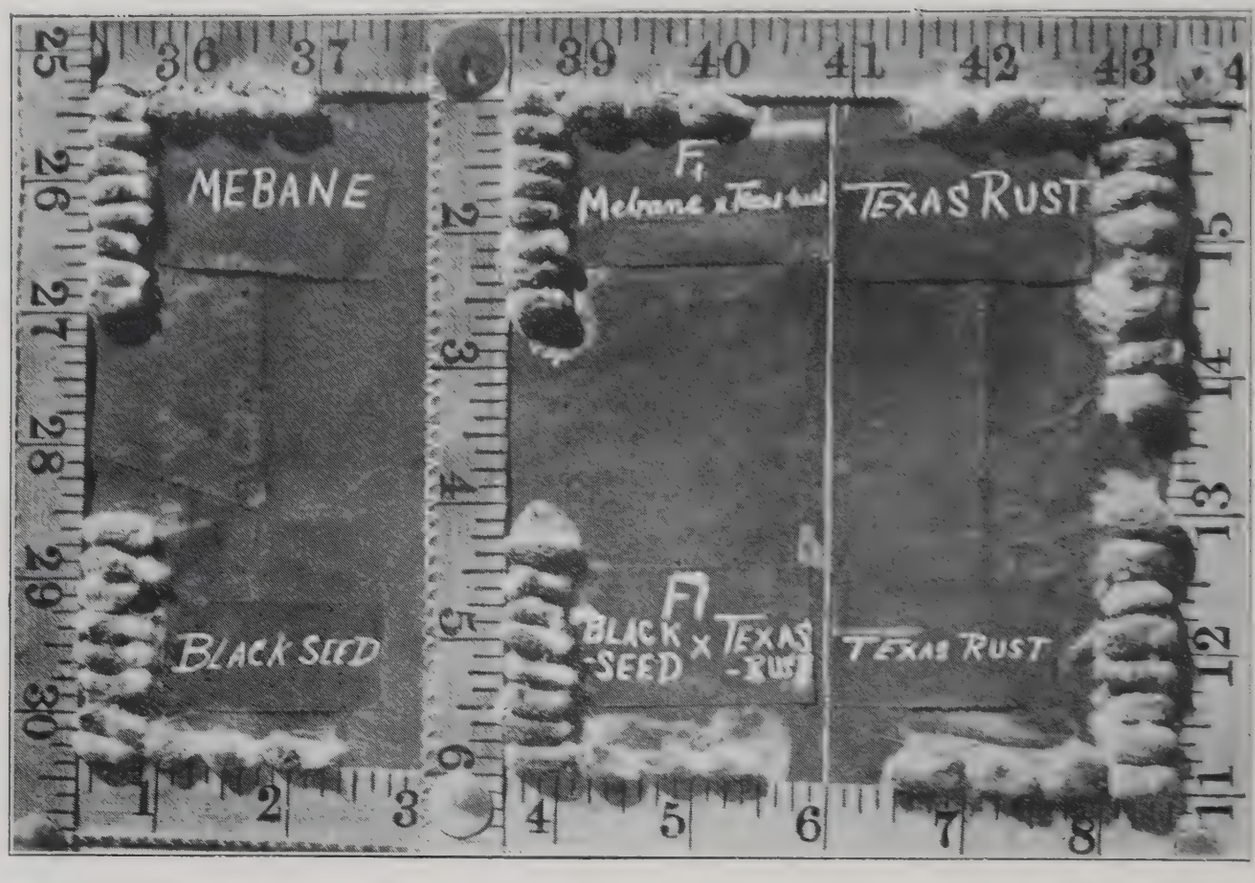

FIG. 1. *Top (from left).* Felted parent, F_1 hybrid, woolly parent.
Bottom (from left). Scanty fuzz parent, F_1 hybrid, woolly parent.

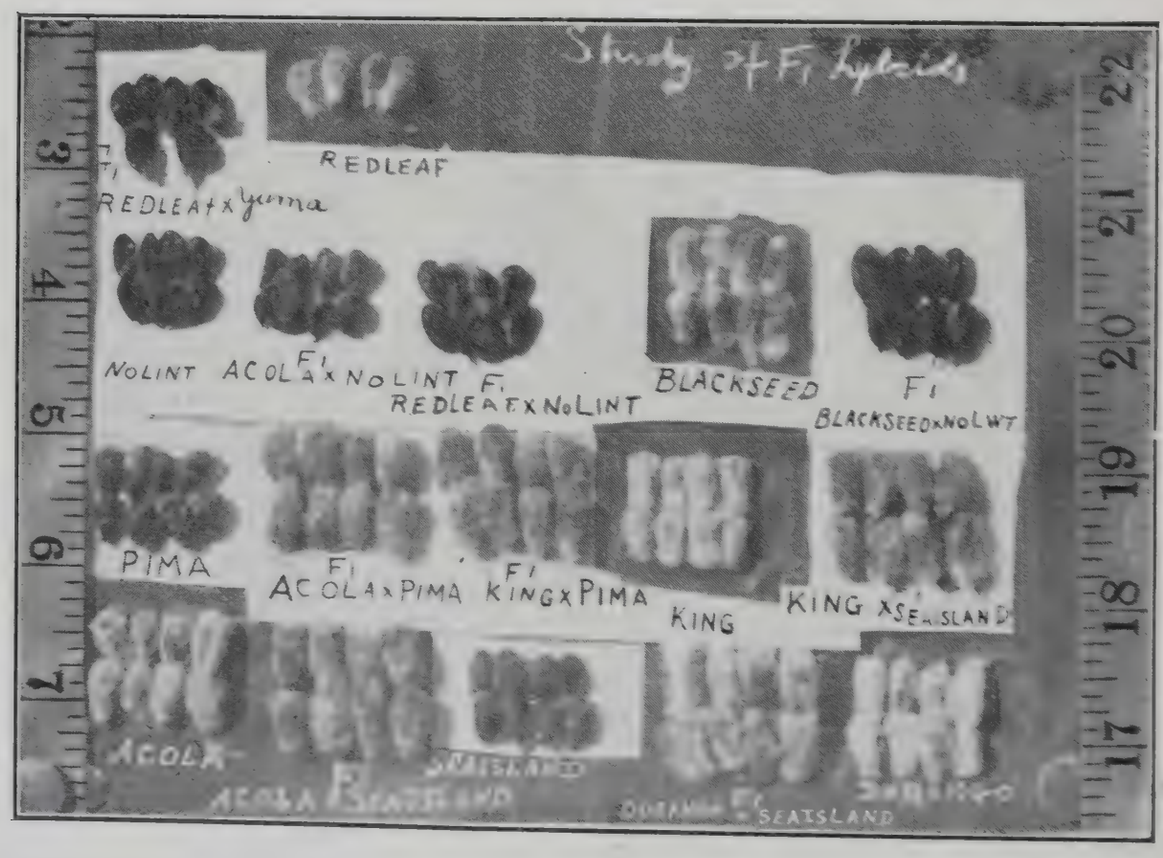

FIG. 2. *Top (from left).* 1, Entirely fuzzy × partially fuzzy; 2, Entirely fuzzy parent.
Second row: 1. Naked seed parent; 2 & 3. Wholly fuzzy × naked; 4. Scanty fuzzy parent; 5, Scanty fuzz × naked.
Third row: 1, Partially fuzzy parent; 2 & 3, Wholly fuzzy × partially fuzzy; 4, Wholly fuzzy parent; 5, F_1 Upland × Sea Island.
Bottom. 1, Wholly fuzzy parent; 2, King Upland × Sea Island; 3, Sea Island parents; 4, Durango × Sea Island; 5, Durango.

Entirely fuzzy seeds. As already mentioned, there are three sub-divisions of entirely fuzzy seeds, *viz.*, woolly, felted, scanty fuzz. In the cross Felted × Woolly, felted seed was dominant (Plate I, fig 2 ; Plate II. fig. 1), and the F_2 generation was too small to compute a ratio. In the cross Scanty Fuzz × Woolly, scanty fuzz was dominant (Plate I, fig. 2) and the F_2 generation in this case also was too small.

It may be interesting to observe that Balls in his early investigations came to the conclusion that 'little fuzz' is dominant over 'no fuzz' and 'entire fuzz' dominant over 'little or no Fuzz.' Similar results are reported by McLendon. These results are often cited by cotton investigators as generally true but our experiments show that the reverse is the case. Thus the forms which are indistinguishable phenotypically may not necessarily have the same genetic constitution. Balls was dealing with Egyptian crosses while the experiments here described refer to American Upland crosses. Cases of factor interaction are also widely known. The plant breeder must, therefore, take caution in accepting the results of certain crosses as being generally applicable to all cottons.

Partially fuzzy seeds. All Egyptian cottons and some strains of Sea Island cotton come under this class. These when crossed with entirely fuzzy seed of American Upland cottons show that the latter are dominant in the F_1 generation except in one case, which will be treated separately. In the F_2 generation the ratios obtained varied in the several crosses, in one case 19 individuals of entirely fuzzy type and 1 of partially fuzzy type were found ; many plants were infertile. F_2 population presented such a mass of heterogeneous individuals as would permit of no grouping. Apparently several factors are involved in these crosses. These results are in agreement with those obtained by Balls and McLendon since the crosses were identically the same.

The Yuma variety of Egyptian cotton has a seed-coat which is mostly naked except small tufts of fuzz at the ends extending along the raphe. This seed when crossed with entirely fuzzy seed of American Upland cottons behaves differently from other Egyptian and Sea Island cottons grouped under "partially fuzzy seeds" in being dominant over the Upland type (Plate II, fig 2). In the F_2 generation five kinds of seeds were obtained ranging in seed fuzziness from absolutely naked seeds to entirely fuzzy seeds. The ratios obtained were as follows :—

TABLE II.

F_2 segregation, Egyptian-Upland cross, Yuma × Red Leaf.

Phenotype	No. of individuals
1. Entirely naked seed	3
2. Seed almost naked with little fuzz at one end	5
3. Yuma type of seed with very little fuzz at two ends and along raphe	10
4. Entirely fuzzy (felted green)	10
5. Entirely fuzzy (woolly)	10

The behaviour of this cross in the F_2 generation shows that many factors are involved. F_3 generation has not been grown. Kearney[1] has also observed a similar behaviour of the Yuma variety. He states " the apparent dominance of a less fuzzy over a more fuzzy condition of the seed-coat in this presumably first generation hybrid is exceptional, since according to Balls 'little fuzz' is dominant over 'no fuzz' and 'entire fuzz' is dominant over 'little or no fuzz.'"

2. Inheritance of amount of Lint on the Seed.

This character has been investigated by McLendon.[2] In a cross of Sea Island with Cook's Big Boll (an Upland variety), McLendon states, 'low percentage' is dominant to 'high percentage' and in the F_2 generation the original percentages reappear, with variations extending even beyond the extremes of the parental percentages. This pair of characters behaves differently in the varietal crosses of American Upland cottons as compared to the behaviour of the interspecific crosses quoted above. In these experiments it is found that 'high percentage' is dominant over 'low percentage' in the varietal crosses of American Upland cotton as noticed in the following crosses :—

(1) No Lint × Lonestar.
(2) No Lint × Texas Rust.
(3) No Lint × Acala.
(4) No Lint × Red Leaf.

The amount of lint is measured by lint percentage and also by lint index. The latter gives the weight of lint on 100 seeds and is not much affected by the size of the seed as would be the case in calculating the lint percentage ; and hence it is more accurate an expression of the amount of lint. In these crosses the No Lint parent has a lint index of 0–1 (grm. of lint per 100 seeds) as compared to the lint index of the other American Upland varieties ranging from 3–5·5 (grm. of lint per 100 seeds). The percentage of No Lint variety ranges from 0–10 and that of the other American Uplands from 26–36. The parents are easily distinguishable by the naked eye, although in some crosses actual weights have been taken as a check measure.

The following ratios have been obtained in the F_2 generation :—

Table III.

Segregation of high amount of lint versus low amount of lint in cotton.

Serial No.	Cross	No. of individuals in F_2			Remarks
		High	Low	Total	
1	No Lint × Lonester . . .	14	5	19	
2	No Lint × Texas Rust . .	41	14	55	
3	No Lint × Red Leaf . . .	58	19	77	
4	No Lint × Acala . . .	101	35	136	
	Observed Totals . . .	214	73	287	
	Calculated	215·25	71·75	387	

[1] Kearney, T. H. *Jour. Agri. Res.*, May 16, 1921, p. 229.
[2] McLendon. *Ibid.*

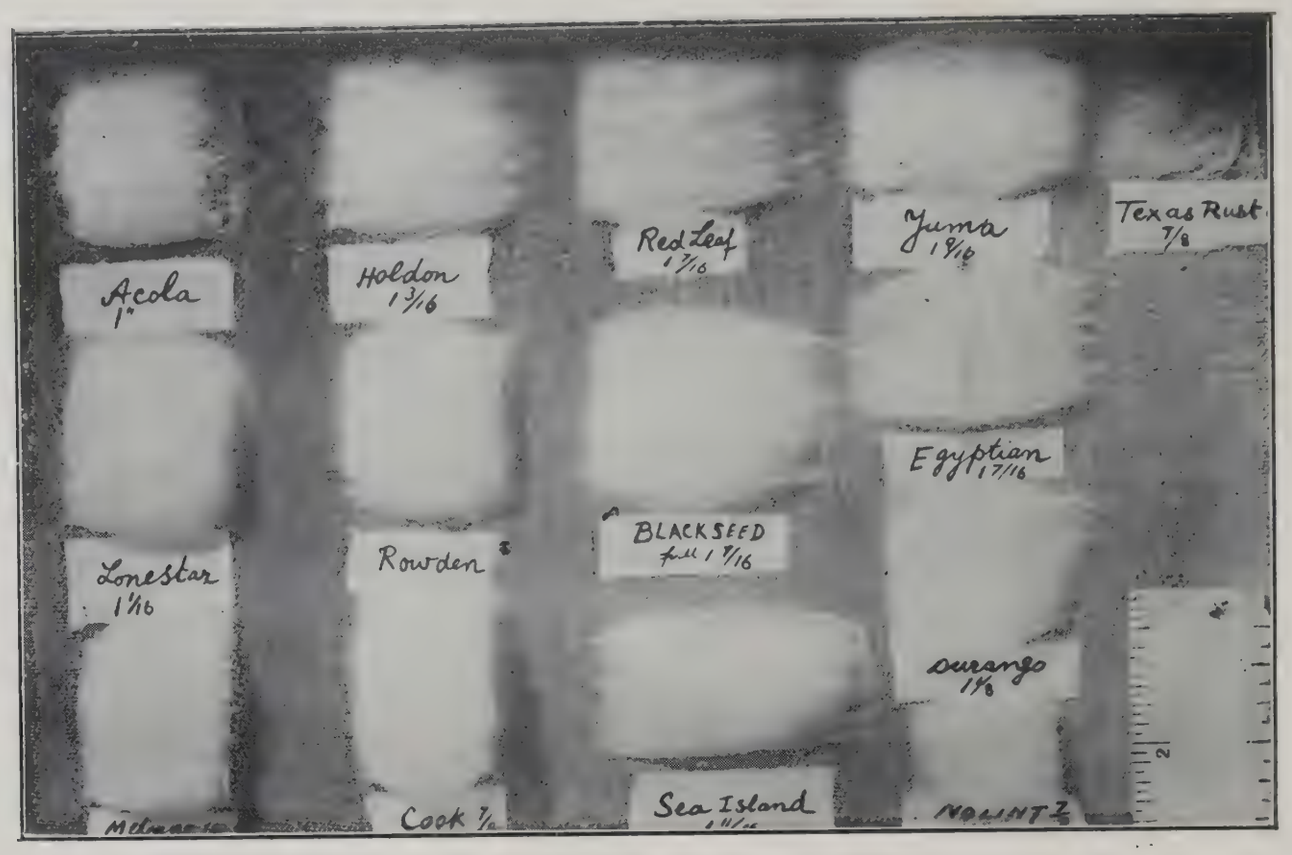

FIG. 1. Lint length of parents.

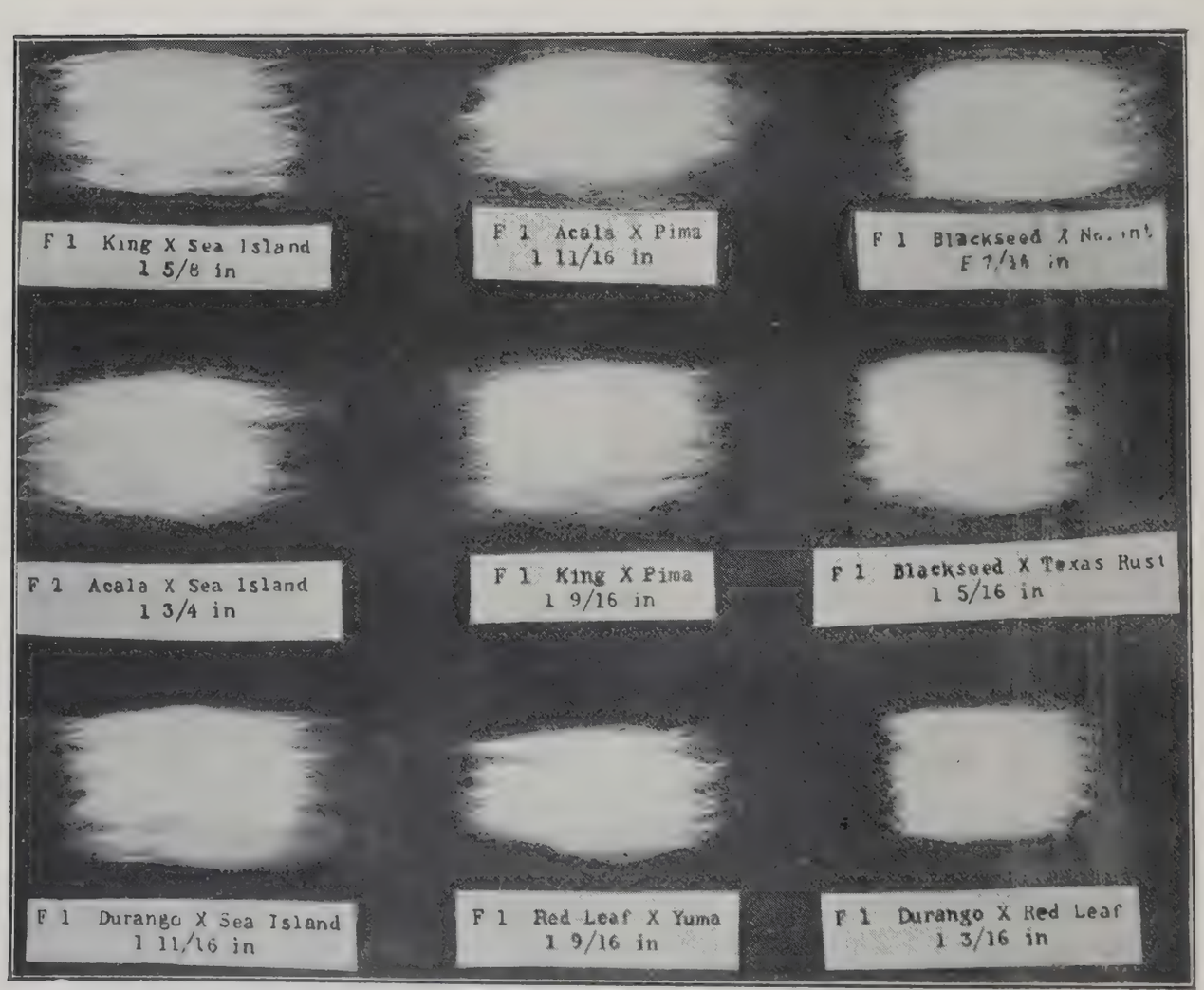
F 1 King X Sea Island 1 5/8 in
F 1 Acala X Pima 1 11/16 in
F 1 Blackseed X Nolint F 7/16 in
F 1 Acala X Sea Island 1 3/4 in
F 1 King X Pima 1 9/16 in
F 1 Blackseed X Texas Rust 1 5/16 in
F 1 Durango X Sea Island 1 11/16 in
F 1 Red Leaf X Yuma 1 9/16 in
F 1 Durango X Red Leaf 1 3/16 in

FIG. 2. Lint length of F_1 hybrids.

The ratios obtained indicate that a single factor is involved in this pair of characters, and expectations were fulfilled in the F_3 generation.

3. Inheritance of length of lint.

It is a matter of common knowledge that some cottons are long-stapled and others short-stapled. Long staple seems to be dominant over short in the F_1 generation as found in the following crosses (Plate III).

Table IV.

Staple length of parents and F_1 hybrids.

One Parent		Other Parent		F_1 Hybrid
Variety	Length in inches	Variety	Length in inches	Length in inches
I. Interspecific cross.				
Sea Island	$1\frac{11}{16}$	Acala (Upland)	1	$1\frac{3}{4}$
Sea Island	$1\frac{11}{16}$	Durango (Upland)	$1\frac{1}{8}$	$1\frac{11}{16}$
Sea Island	$1\frac{11}{16}$	King (Upland)	$\frac{7}{8}$	$1\frac{5}{8}$
Pima (Ariz. Egyptian)	$1\frac{5}{8}$ to $1\frac{3}{4}$	Acala (Upland)	1	$1\frac{11}{16}$
Pima (Ariz. Egyptian)	$1\frac{5}{8}$ to $1\frac{3}{4}$	King (Upland)	$\frac{7}{8}$	$1\frac{9}{16}$
Yuma (Ariz. Egyptian)	$1\frac{9}{16}$	Red Leaf (Upland)	$1\frac{7}{16}$	$1\frac{9}{16}$
II. Varietal cross.				
Black Seed (Upland)	$1\frac{7}{16}$	Texas Rust (Upland)	$\frac{7}{8}$	$1\frac{3}{16}$
Black Seed (Upland)	$1\frac{7}{16}$	No Lint (Upland)	$\frac{7}{8}$	$1\frac{1}{4}$
Red Leaf (Upland)	$1\frac{7}{16}$	Texas Rust (Upland)	$\frac{7}{8}$	$1\frac{1}{8}$

The F_2 generation in some crosses could not be investigated for reasons beyond control; in others the ratios obtained varied in the several crosses so that no theoretical ratios seem to be suggested in the counts. In the F_2 population of the interspecific crosses there was a great tendency towards sterility.

Conclusions.

1. Forms which are indistinguishable phenotypically may not have the same genetic constitution and hence the mode of inheritance in certain crosses may vary

for the visibly similar characters in other crosses. Hence the plant breeders are cautioned to accept the results of crossing experiments as being generally applicable without reference to the types involved in the cross.

2. Most of the characters of economic significance show dominance in the F_1 generation and hence the desirable combinations are not so easy to segregate as would be the case if the desirable characters were recessive. In the case of seed fuzziness it is however found that the fuzzy seed is recessive to naked seed. Since many of the American Upland cottons often contain a few naked seeds, advantage of recessive nature of the fuzzy seed may be taken in purifying the crop by mechanically removing the naked seeds.

3. The significance of the study of the mode of inheritance in staple crops is of vital interest in agriculture, since improvement of crops is one of the most fundamental lines of progress.

SELECTED ARTICLES

PRESENT-DAY PROBLEMS IN CROP PRODUCTION.*

BY

SIR E. JOHN RUSSELL, F.R.S.

COMPLEXITY OF THE PROBLEM.

THE agricultural investigator is confronted with three closely interlocking agencies—the plant, the climate and the soil—each of which is variable within certain limits, and each playing a large part in the crop production which it is his business to study.

Confronted with a problem of this degree of complexity there are two methods of procedure: the empirical method of field observations and experiments in which there is no pretence of great refinement and no expectation that the same result will ever be obtained twice, it being sufficient if over an average of numerous trials a result is obtained more often than would be expected from the laws of chance; and the scientific method, in which the factors are carefully analysed and their effects studied quantitatively; a synthesis is then attempted, and efforts are made to reconstruct the whole chain of processes and results. The scientific method is of course, the one to which we are naturally attracted. But common truthfulness compels one to admit that up to the present the greatest advances in the actual production of crops have been effected by the empirical method, and not infrequently by men who are really artists rather than men of science, in that they are guided by some intuitive process which they cannot explain, and that they have the vision of the result before they obtain it, which the scientific man commonly has not.

The best hope for the future lies in the combination of the empirical and the scientific methods. This is steadily being accomplished by the recent strong infusion of science into the art of field experimentation, which has much enhanced the value of the field work and the trustworthiness of its results. Modern methods of replication, such as have been worked out at Rothamsted and in the United States by Harris of the Carnegie Trust (Cold Spring Harbour), Kiesselbach in Nebraska, Myers and Love of Cornell, and others, constitute a marked improvement in plot technique. The figures themselves, besides being more accurate, can be made to yield more information than was formerly the case.

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* From the presidential address delivered to Section M (Agriculture) of the British Association, Toronto, 1924. Reprinted from *Nature*, No. 2864.

Great advances have been made in the methods of analysing the results. The figures are never the same in any two seasons, since the climatic conditions profoundly affect the yields. A few men, like J. H. Gilbert, have the faculty of extracting a great deal of information from a vast table of figures, but in the main even the trained scientific worker can make very little of them. The reason is that he has been brought up to deal with cases where only one factor is varying, while the growth of plants involves the interaction of three variable factors : the plant, the soil, and the climate. It is impossible to apply in the field the ordinary methods of the scientific investigator where single factors alone are studied ; very different methods are needed, adapted to the case, where several factors vary simultaneously.

Fortunately for agricultural science, statisticians have in recent years worked out methods of this kind, and these are being modified and developed by R. A. Fisher and Miss Mackenzie for application to the Rothamsted field data. It so happens that this material is very suitable for the purpose, since a large number of the field experiments have been repeated every year for seventy or eighty years on the same crop and on the same piece of land, using the same methods ; the field workers also remain the same for many years, the changes being rare and without break in continuity . Although the statistical investigation is only recently begun, mathematical expression has already been given to the relationship between rainfall and yield of wheat and barley under different fertilizer treatments, and precision has been given to some of the ideas that have hitherto been only general impressions. If on an average of years a farmer is liable to a certain distribution of rainfall, it is becoming possible to advise as to fertilizer treatment which enables the plant to make the best of this rainfall.

Alterations in the Plant.

It is a commmonplace among farmers that certain soil conditions influence not only the yield but also the quality of crops. The leaf and root are more easily affected than the seed. The case of mangolds has been investigated at Rothamsted ; the sugar content of the root, an important factor in determining feeding value, was increased by increasing the supply of potassium to the crop. Middleton at Cockle Park showed that grass increased in feeding value—quite apart from any increase in quantity—when treated with phosphates. Potatoes are considerably influenced by manuring ; increasing the supply of potassium influences the composition of the tubers and also that much more impalpable quality—the cook's estimate of the value of the potato ; while we have found at Rothamsted that a high class cook discriminated between potatoes fertilized with sulphate of potash and those fertilized with muriate of potash, giving preference to the former.

Grain is more difficult to alter by changes in environmental conditions ; indeed, it appears that the plant tends to produce seed of substantially the same composition whatever its treatment—with the important exception of variation in moisture

supply. Mr. Shutt has explored the possibilities of altering the character of the wheat grain by varying the soil conditions, and finds that increases in soil moisture decrease the nitrogen in the grain. Similar results have been obtained in the United States.

On the other hand, in England the reverse seems to hold, at any rate for barley. This crop is being fully investigated at the present time under the research scheme of the Institute of Brewing, because of its importance in the preparation of what is still Britain's national beverage. Increased moisture supply increases the percentage of nitrogen in the grain, and so also does increased nitrogen supply, though to a much less extent; on the other hand, both potassic and phosphatic fertilizers may decrease the percentage of nitrogen, though they do not always do so; the laws regulating their action are unknown to us.

The practical importance of these problems of regulating the composition of the plant lies in the fact that the farmer can control his fertilizer supply, and also to some extent his moisture supply, so that it lies within his power to effect some change should he wish to do so.

In agricultural science one sometimes thinks only of the crop and the factors that affect its growth. But in agricultural practice there is often another partner in the concern: a pest or parasite causing disease. The amount of damage done by pests and diseases to agricultural crops is astounding; in Britain it is probably at least 10 per cent. of the total value of the crops and the loss is probably some £12,000,000 sterling per annum; in some countries it is considerably more. Indeed, the number of insect pests and of harmful fungi and bacteria that skilled entomologists and mycologists have found in our fields might almost lead us to despair of ever raising a single crop, but fortunately the young plant, like the human child, grows up in spite of the vast number of possible deaths. The saving fact seems to be that the pest does harm only when three sets of conditions happen to occur together: the pest must be present in the attacking state; the plant must be in a sufficiently receptive state; and the conditions must be favourable to the development of the pest. It is because this favourable conjunction of conditions comes but rarely that crops manage to survive; and this gives us the key to control if only we knew how to use it. Complete control of any of these three conditions would end all plant diseases. Unfortunately, control is never complete even in glasshouse culture, still less out of doors. But even partial control would be very helpful. All these pests go through life-cycles, which are being studied in great detail all over the world, and especially in the United States. Somewhere there occurs a stage which is weaker or more easily controlled than others, and the pest would become harmless if the chain could be broken here or if the cycle could be sufficiently retarded to give the plant a chance of passing the susceptible stage before it is attacked.

The plants themselves, as we have just seen, are in some degree under control and if they could be pushed through the susceptible stages before the pest was ready,

they would escape attack. Barley in England is sometimes considerably injured by the gout fly (*Chlorops tæniopus*). The larvæ emerge in spring from the eggs laid on the leaves and invariably crawl downwards, entering the young ear if, as usually happens, it still remains ensheathed in leaves. J. G. H. Frew, at Rothamsted, has shown that early sowing and suitable manuring cause the ear to grow quickly above the track of the larvæ, and thus to escape injury. E. A. Andrews, in India, has found that tea bushes well supplied with potassic fertilizer escape attack from the mosquito bug (*Helopeltis*) for the rest of the season, apparently because bushes so treated become unsuitable as food to the pest. Further, the conditions are alterable. H. H. King, in the Sudan, has effected some degree of control of the cotton thrips (*Heliothrips indicus*) by giving the plant protection against the drying north wind and so maintaining a rather more humid atmosphere—a condition in which the plant flourishes more than the pest. Tomatoes in England suffered greatly from *Verticillium* wilt until it was found that a small alteration of temperature threw the attack out of joint. They are also much affected by stripe disease (*B. lathyri*), but they become more resistant when the supply of potash is increased relative to the nitrogen. It has recently been maintained, though the proof is not yet sufficient, that an altered method of cultivating wheat in England will afford a good protection against bunt. These cultural methods of dealing with plant diseases and pests offer great possibilities, and a close study jointly by plant physiologists and pathologists of the responses of the plant to its surroundings, and the relationships between the physiological conditions of the plants and the attacks of its various parasites, would undoubtedly yield results of great value for the control of plant diseases. Again, however, the plant breeder can save a world of trouble by producing a variety resistant to the disease ; or there may fortunately be found an immune plant from which stocks can be had, as in the case of the potatoes found by Mr. Gough to be immune to the terrible wart disease.

Control of Environmental Factors.

It thus appears that, if only plant breeders and plant physiologists could learn to alter existing plants or to build up new plants in such a way that they should be well adapted to existing soil and climate conditions, and not adapted to receive disease organisms at the time the organisms are ready to come—if only they could do this, all agricultural land would become fertile and plant diseases and pests would become ineffective : at any rate until the pests adapted themselves to the new plants. Although no one can set limits to the possibilities of plant breeding and plant physiology, we cannot assume that we are anywhere near this desirable achievement or that we are likely to be in our time.

There will always remain the necessity for altering the environmental conditions to bring them closer to the optimum conditions for the growth of the plant. No attempt is yet made in the field to control two of the most important of the factors :

the light and the temperature, though it is being tried experimentally. There is a great field for future workers here ; at present plants utilize only a fraction of the radiant energy they receive. At Rothamsted attempts have been made by F. G. Gregory to measure this fraction ; the difficulties are considerable, but the evidence shows that our most efficient plants lag far behind our worst motor-cars when regarded as energy transformers for human purposes. One hundred years ago the efficiency of an engine as a transformer of energy was about 2 per cent. ; now, as a result of scientific developments, it is more than 30 per cent. To-day the efficiency of the best field crops in England as transformers of the sun's energy is about 1 per cent.*: can we hope for a similar development in the next hundred years ? If such an increase could be obtained an ordinary crop of wheat would be about 400 bushels per acre, the farmers would feel sorry for themselves if they obtained only 200 bushels. But we are only at the beginning of the subject. Increases in plant growth amounting to some 20 or 25 per cent. have been obtained by V. H. Blackman in England under the influence of the high-tension electric discharge, which presumably acts by increasing in some way the efficiency of the plant as an energy transformer. Possibly other ways could be found. It needs only a small change in efficiency to produce a large increase in yield. Much could be learned from a study of the mass of data which could be accumulated if agricultural investigators would express their results in energy units as well as in crop yields as at present.

Interesting results may be expected from the attempts now being made in glass-house culture both in Germany and at Cheshunt to increase the rate of plant growth by increasing the concentration of the carbon dioxide in the atmosphere.

Control of the Soil Factors.

The soil factors lend themselves more readily to control and much has already been achieved. Water supply was one of the first to be dealt with. Civilization arose in the dry regions of the earth, and so far back as 5,000 years ago, irrigation was so advanced as a practical method that it came into the ordinances drawn up by the great Babylonian king Hammurabi. The chief problems at the present time are to discover effective means of economizing water and to ascertain, and if possible to control, the relationships between the soil, the water, and the dissolved substances in the water.

Inseparably bound up with water supply are the questions of cultivation and of drainage, which affect not only the water but the air supply to the roots. The former subject is now attracting considerable attention ; the great need is to discover means for expressing cultivation in exact physical and engineering units. The measurements of Keen and Haines at Rothamsted, and the chemical work of A. F. Joseph,

* The remaining energy being largely used up in transpiration. This figure refers to the total radiation received by the leaf, and not to the fraction received by the chloroplast surface. For this latter the value is much higher.

N. Comber, and others on clay, and of Oden Page and of others on humus, indicate the possibility of finding exact expressions and of effecting co-operation with the workers in the new fields of agricultural engineering.

Another soil factor which readiiy lends itself to some degree of control is the amount of plant nutrients present. The possibility of increasing this by means of manure has been so frequently explored in field trials that it has sometimes been regarded as almost a completed story ; indeed, Rothamsted tradition affirms that Lawes himself once gave orders to have the Broadbalk field experiments discontinued because they had nothing further to tell ; it was only the earnest persuasion of Gilbert that caused him to countermand the order. So far from the subject being exhausted, it still bristles with problems. The new nitrogenous fertilizers, resulting from war-time activities in nitrogen fixation ; the need for reducing the cost of superphosphate ; the change in character in basic slag ; and the Alsatian development in potash production, are producing changes in the fertilizer industry the full effects of which are not easy to foresee. Economic pressure is driving the farmer to derive the maximum benefit from his expenditure on fertilizers, lime, farmyard manure, and other ameliorating agents, and is compelling a more careful study of possibilities hitherto disregarded, such as the use of magnesium salts, silicates, and sulphur as fertilizers, and above all, a much more precise diagnosis of soil deficiencies than was thought necessary in pre-war days.

There are, however, more fundamental problems awaiting solution. It is by no means certain that we know even yet all the plant nutrients. The list compiled by Sachs many years ago includes all needed in relatively large amounts, but Gabriel Bertrand has shown that it is not complete and that certain substances—he studied especially manganese—are essential although only in very small amounts. Miss Katherine Warington, working with Dr. Brenchley at Rothamsted, has shown that leguminous plants fail to develop in the so-called complete culture solution unless a trace of boric acid is added. Maze has indicated other elements needed in small amounts.

Another problem needing elucidation is the relationship between the quantity of nutrients supplied and the amount of dry matter produced. Is dry matter production simply proportional to nutrient supply, as Liebig argued, with the tailing off beyond a certain point, as demonstrated by Lawes and Gilbert, or is it always less than this, as indicated by Mitscherlich's logarithmic curve ; or is the relationship expressed by one of the more complex sigmoid curves as there is some reason to suppose ? We do not know ; and the problem is by no means simple, yet it governs the " diminishing returns " about which farmers hear so much.

Again, very little is known of the relationship between nutrition and the period of growth of a plant. One and the same quantity of a nitrogenous fertilizer, for example, may have very different effects on the plant according as it is given early or late in life ; not only is there a difference in quantity of growth but also in the

character of growth. Late dressings cause the characteristic dark-green colour to appear late in the season, and thus affect the liability to fungoid diseases ; they increase the percentage of nitrogen in the grain and they may give larger increases of crop than early dressings.

Investigations are needed to find the best methods of increasing the supply of organic matter in the soil and its value for the different crops in the rotation.

All these problems will sooner or later find some solution. But there remains a greater problem of more importance than any of them : the linking-up of plant nutrition studies with those of the soil solution. As our cousins in the United States were the first to emphasize, the fundamental agent in the nutrition of the plant is the soil solution, and they made a remarkable series of investigations into what appeared at one time a hopeless proposition—the physico-chemical interactions between the soil and the soil water. A great advance in crop production may be expected when the soil chemists have discovered the laws governing the soil solution, when the plant physiologists can give definite expression to the plant's response to nutrients, and when some one is able to put these results together and show how to alter the soil solution so that it may produce the maximum effect on the plant at the particular time. The new soil chemistry will yet have its triumphs.

The Soil Micro-organisms.

It is now more than forty years since the discovery of the great importance of micro-organisms in determining soil fertility. Practical applications necessarily lag far behind ; but already three have been made each of which opens out great possibilities for the future. The long-standing problem of inoculation of leguminous crops with their appropriate organisms has already been solved in one or two of its simple cases, chiefly lucerne on new land, and the new process has helped in the remarkable extension of the lucerne crop in the United States and in Denmark. We believe at Rothamsted that the more difficult English problem is now solved also. Interesting possibilities are opened up by the observation that a preliminary crop of Bokhara clover seems to facilitate the growth of the lucerne.

The organisms effecting decomposition are now coming under control, and are being made to convert straw into farmyard manure (or a material very much like it) without the use of a single farm animal. The process was worked out at Rothamsted, and is being developed by the Adco Syndicate, which is now operating it on a large scale and is already converting some thousands of tons of straw annually into good manure.

The third direction in which control of the soil organisms is being attempted is by partial sterilization. This process is much used in the glasshouse industry in England, and it has led to considerable increases in crop yields. The older method was to use heat as the partial sterilizing agent, and this still remains the most effective,

but owing to its costliness, efforts have been made to replace it by chemicals. Considerable success has been attained ; we have now found a number of substances which seem promising. Some of these are by-products of coal industries ; others, such as chlor and nitro-derivatives of benzene or cresol, are producible as crude intermediates in the dye industry.

The Need for fuller Co-operation.

Looking back over the list of problems it will be seen that they are all too complex to be completely solved by any single worker. Problems of crop production need the co-operation of agriculturists, plant physiologists, soil investigators, and statisticians. Even plant breeding necessitates the help of a physiologist who can specify just what the breeder should aim at producing. This gives the key-note to the period of agricultural science on which we have now entered—it is becoming more and more a period of co-operation between men viewing the problem from different points of view. Good individual work will of course always continue to be done, but the future will undoubtedly see a great expansion of team work such as we know from our experience at Rothamsted is capable of giving admirable results in agricultural science.

With fuller co-operation both of men and of institutions we could do much to overcome the present difficulty in regard to utilizing the information we already possess. In the last thirty years an immense stock of knowledge has been obtained as to soils and crops. It is stored in great numbers of volumes which line the shelves of our libraries, and there much of it rests undisturbed in dignified oblivion. In the main it consists of single threads followed out more or less carefully ; only rarely does some more gifted worker show something of the great pattern which the threads compose. But even the most gifted can see but little of the design ; the best hope of seeing more is to induce people to work in groups of two or three, each trained in a different school and therefore looking at the problem from a different point ; each seeing something hidden from the rest. Unlike art science lends itself to this kind of team work ; art is purely an individual interpretation of Nature while science aims at a faithful description of Nature, all humanistic interpretation being eliminated. There is certainly sufficient good will among the leaders of agricultural science to justify the hope of co-operation ; there are probably in existence foundations which would furnish the financial aid.

This leads to my last point. What is the purpose of it all ? Team work, co-operation, the great expenditure of time and money now being incurred in agricultural science and experiment—these are justified only if the end is worthy of the effort.

The nineteenth century took the view that agricultural science was justified only in so far as it was useful. That view we now believe to be too narrow. The practical purpose is of course essential ; the station must help the farmer in his

daily difficulties—which again necessitates co-operation, this time between the practical grower and the scientific worker. But history has shown that institutions and investigators that tie themselves down to purely practical problems do not get very far ; all experience proves that the safest way of making advances, even for purely practical purposes, is to leave the investigator unfettered. Our declared aim at Rothamsted is " to discover the principles underlying the great facts of agriculture and to put the knowledge thus gained into a form in which it can be used by teachers, experts, and farmers for the upraising of country life and the improvement of the standard of farming."

This wider purpose gives the investigator full latitude, and it justifies an investigation whether the results will be immediately useful or not—so long as they are trustworthy. For the upraising of country life necessitates a higher standard of education for the countryman ; and education based on the wonderful book of Nature which lies open for all to read if they but could. How many farmers know anything about the remarkable structure of the soil they till, of its fascinating history, of the teeming population of living organisms that dwell in its dark recesses ; of the wonderful wheel of life in which the plant takes up simple substances and in some mysterious ways fashions them into foods for men and animals and packs them with energy drawn out of the sunlight—energy which enables us to move and work, to drive engines, motor-cars and all the other complex agencies of modern civilization ? No one knows much of these things ; but if we knew more and could tell it as it deserves to be told, we should have a story that would make the wildest romance of human imagination seem dull by comparison and would dispel for ever the illusion that the country is a dull place to live in. Agricultural science must be judged not only by its material achievements, but also by its success in revealing to the countryman something of the wonder and the mystery of the great open spaces in which he dwells.

Sir John Russell writes in " Nature," dated 1st November, 1924 :—

On returning from a lecturing tour in Canada and the United States, I find among the files of *Nature* " Cantab's " interesting letter in the issue of 27th September.

I had no intention of being despondent in my address to Section " M " (Agriculture) of the British Association, nor is there occasion for despondency. It is true that science has given only few aids to agriculture of the order of 100 per cent. increase in yield, but much has been done of a less spectacular nature, and agricultural experts are now able to advise farmers with considerably more certainty than was the case even thirty years ago. There have been great changes in practice, and science has helped considerably. The history of agriculture shows that advances have come in three ways : from purely empirical methods tried by farmers with no definite scientific plan ; from experiments on empirical lines made by trained workers ;

and from advances in pure science, whether initiated in a purely scientific, or, as has often happened, in a technical laboratory. It is a fact that in the past some of the biggest advances have been made by empirical methods, but one cannot infer that scientific methods are therefore inferior ; only in recent years have they been adequately tried. Our knowledge of the biochemical changes in the soil, of the soil micro-organisms, the soil solution, and the soil colloids, quite apart from the genetical work to which " Cantab " referred, has all come as the result of the purely scientific work, done solely with the view of gaining information, and with no idea of practical applications. Little of this knowledge is yet used in practice, for the simple reason that no one has found a way of using it, but all history shows that the application comes sooner or later once the scientific discovery is definitely established. There is every reason to hope that agricultural science has fresh triumphs in store.

In recent years it has been easier to apply scientific methods in agricultural investigations because many of those responsible for the management of agricultural institutions, and especially the younger men, appreciate their value and realize the necessity for the so-called " academic work." No honest person working on scientific lines would ever commit himself to a definite promise that a particular investigation would have practical results ; he can, however, so conduct it that it will yield sound knowledge. It is of course true, as " Cantab " points out, that epoch-making discoveries have not yet come direct from team work or directed research. But it must also be recognized that advances of this order are in any case very rare, and when they come it is largely as the result of the less spectacular, but none the less real, advances in knowledge which can be made in the well-equipped organized institution. No research institution can do more than hope for first order discoveries, but the staff can, at any rate, ensure good development work, and secure advances which in the aggregate count for much.

Like all other forms of research, agricultural research is finally limited by the state of knowledge of other branches of science ; and a logical scheme of assistance would recognize the claims of all pure science. The present schemes may not be very logical, but knowing something of the methods by which a research institute has to be sustained, I am not sure that the departments of pure science have always adopted the best methods for obtaining assistance. A great difficulty of research institutions—and it must be far greater to the layman—is to know just what are the methods and the results of science, in other words, whether the limitation imposed by lack of knowledge in pure science lies in the man or the science. The agricultural investigator received his training in pure science it may be ten or twenty years ago ; he tries to keep up, but is overwhelmed by the enormous and ever-increasing volume of papers of very varying merit and lucidity. The Chemical Society facilitates his task by issuing annual reports on the different branches of chemistry, and many other scientific societies have not followed this good example. There must be many papers in pure science buried in the libraries which would prove of great value to agriculture if they were known, but they are not. At Rothamsted we have

adopted various devices for keeping in touch with pure science, one of the best of these being to bring young men and women from the purely scientific laboratories from time to time to take part in our work. This is one example of the " team work " to which I referred in my address as being among the hopeful ways of securing advances in agricultural science, another being co-operation between institutions engaged on different aspects of what may be fundamentally one and the same problem.

Team work makes it possible for the different workers to keep in touch, and to utilize advances made in other subjects. It has other advantages too, for even the wisest of mortals will never see a scientific problem as a whole, but only in part.

THE PRACTICAL AIMS OF THE DAIRY FARMER.*

BY

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THE chief practical aim of the dairy farmer must of necessity be the same as that of any other business man who invests his capital in some form of industry, namely, the obtaining of the largest average net profit over a period of years.

This aim can only be realized by good all-round management, and farm management includes many operations of very diverse character, such as purchase of live-stock, feeding stuffs, manures, etc., of the kinds most suitable for the farm in the most economical manner; efficient organization of labour; selection of the most suitable crops, followed by adequate cultivation and good judgment at harvesting; wise use of home-grown and purchased foods; careful treatment of all kinds of live-stock, and the sale of milk, dairy produce, surplus stock and crops in the most advantageous manner.

The second practical aim of the dairy farmer must, therefore, be successful management of those branches of the farm organization which contribute most largely to the annual expenditure and the annual receipts. It is difficult to arrange these branches in a generally accepted order of importance, and fortunately this is not essential; some stand out clearly as absorbing major portions of the annual payments, *e.g.*, purchase of feeding stuffs, manures and seeds, occasional purchase of in-calf heifers and cows, and expenditure on labour; others are equally definite as the chief contributions to the annual income, *e.g.*, sale of milk and dairy produce, surplus live-stock and surplus crops. In addition to the actual buying and selling, there is the important work of using the commodities purchased in the most advantageous manner for the production of the goods to be sold. This article will, therefore, be devoted to a brief consideration of the aims of the dairy farmer in each of the above-mentioned branches of the farm management.

PURCHASE AND USE OF FEEDING STUFFS.

Numerous investigations have shown that the cost of purchased feeding stuffs is one of the largest items in the cost of milk production, hence the need for careful

* Reprinted from *Jour. Min. Agri.*, XXXI, p. 516.

study of the composition and nutritive value of available cake and meals in relation to price and suitability for use along with home-grown foods. The aim of the farmer should be to provide a balanced ration of suitable foods at the minimum cost. The home-grown foods—hay, straw, roots, silage, cereal grains, beans, etc.,—usually constitute the bulk of the ration, and purchase of other foods must be made in accordance with the supplies already on the farm. Space does not permit of a detailed discussion here of the principles and practice of feeding, but every dairy farmer ought to have, for easy reference,[1] information on (*a*) the composition of feeding stuffs ; (*b*) the work done in the animal body by the different constituents—albuminoids, oil, etc. ; (*c*) at least one method of valuing feeding stuffs according to their analysis, and he should also be familiar with the so-called feeding standards for milk production which specify the quantities of food needed to maintain the dairy cow in ordinary condition and to produce a given quantity of milk. The use of these feeding standards, combined with a knowledge of the composition of feeding stuffs, has given excellent results in the compounding of rations and in lessening the cost of milk production in many countries.

One instance of the value of such knowledge may be given. In the early winter of 1923 two of the cheapest feeding stuffs on the market were rice meal (£7 per ton), and extracted undecorticated groundnut meal (£6 15*s.* per ton). Reference to the analysis of these foods showed that the former contained : albuminoids 13 per cent., oil 13 per cent., and cabohydrates 50 per cent. ; starch equivalent, 72. The latter contained : albuminoids 32 per cent., oil 2 per cent., and carbohydrates 22 per cent.; starch equivalent, 45.

When mixed in equal proportion in weight, the mixture contained 22½ per cent. albuminoids, 7 per cent. oil, 36 per cent. carbohydrates, with a starch equivalent of 58·5, and cost £6 17*s.* 6*d.* per ton. A further study of tables of food compositions showed that the percentage of digestible albuminoids would be about 17, and this percentage, with a starch equivalent of 58·5, would give a fairly well balanced mixture for milk production ; one in fact, which would fit in very well with an average maintenance ration of home-grown roots and hay. With regard to price, comparison with other feeding stuffs showed that, with two exceptions, the above-mentioned mixture was obtainable at a price per ton appreciably lower than any other single food or mixture of foods of similar composition on the market ; in fact, numerous other foods with similar percentages of albuminoids and oil were quoted at £9 or thereabouts per ton. The exceptions just referred to were palm kernel (extracted) meal and palm kernel cake. A glance at the composition of these foods, however, showed that either of them could be used in equal proportions, along with the rice

[1] *Min Agri., London, Miscellaneous Publication* No. 32 (Rations for live-stock).

meal and groundnut meal, and the resulting mixture would still be well balanced for cows in milk; for example :—

	Albuminoids		Oil Total	Carbo-hydrates Total	Fibre Total	Starch equivalent Total
	Total	Digest.				
Rice meal	13	7	13	50	7	72
Undec. extr. groundnut meal	32	27	2	22	24	45
Extr. palm kernel meal .	19	16	2	49	16	71
Mixture	21·3	16·6	5·6	40·3	15·6	62·6

The percentage of indigestible fibre in the above mixture is higher than is desirable for heavy milking cows, but for average herds a mixture of the above composition has been proved quite satisfactory. Other mixtures containing less indigestible fibre and consisting of more appetising ingredients could easily have been made up, but when the relative costs per ton were compared, the advantage on the side of the cheaper mixture was a strong argument in favour of its use, at least for the first three gallons produced per cow. Cows giving higher daily yields could be given a more appetising mixture for the gallons yielded over three per day.

The fact that in one season market prices of feeding stuffs should vary so much that one or two properly balanced mixtures can be obtained for fully £2 per ton less than other foods of similar analysis constitutes a very practical reason why dairy farmers should have a knowledge of the principles and practice of rationing for milk production. Consideration should also be given to the probability that feeding stuffs can be purchased more cheaply during the summer than during the winter, and it is certain that the price per ton can be cut somewhat when an order is given for a large quantity of one kind of food. There is a certain amount of risk in buying forward, but on the average the purchaser gains; it is usually possible to get sufficient information during the summer as to the trend of prices, and it is preferable to consider groups of alternative foods rather than individual varieties.

There is a wealth of evidence that the important point in a ration is a correct balancing of the albuminoids, carbohydrates, etc., rather than the inclusion of any one or two particular foods, and the object of the farmer should be to purchase such foods as will give a properly balanced ration in conjunction with those grown on the farm.

The benefit obtainable by purchasing a large quantity of any food is fully appreciated by the large farmer, but this advantage can also be obtained by those farming on a smaller scale if they will agree to use the same foods and pool their orders. This

can be done privately, but a large development of this principle should lead to the formation of a co-operative society to organize purchases on a still larger scale.

Purchase and use of Manures and Seeds.

The amount spent annually by the dairy farmer on manures and seeds is as a rule materially less than the expenditure on purchased foods, and the importance of these items in the annual expenditure will naturally vary according to the proportion of arable and grass on the farm.

The principles governing the selection of manures for different soils and crops are now generally understood, and information on the current prices per unit is easily available as a guide to the farmer in the purchase of his requirements. It is nevertheless desirable to emphasize two points ; firstly, the importance of obtaining manures of high grade and reliable quality, and, secondly, the comparison of the cost per unit when the railway carriage, cartage and cost of application is taken into account in addition to the first cost of manure. For example, a grade of basic slag with 20 per cent. total phosphate may be quoted at 41*s*. per ton, equal to 2·05*s*. per unit, and a grade with 34 per cent. total phosphate at 63*s*. per ton, equal to 1·86*s*. per unit. These figures show only a slight difference in favour of the higher grade, but further consideration shows that 6 tons of the latter will supply as much phosphate as 10 tons of the former. The purchase of the higher grade, therefore, means a distinct saving in railway carriage and cartage, and in the cost of application per acre.

With regard to the purchase of seeds all that need be said here is to urge the importance of buying always clean seed of excellent quality.

Purchase of Heifers, Cows and Bulls.

From the point of view of the prospective dairy farmer the purchase of heifers and cows to constitute the foundation of a herd is of the greatest importance, and were this article written primarily for beginners, this subject would have received first consideration. On the other hand, a very large number of dairy farmers are able to maintain their herds by the introduction of home-bred stock and rarely purchase heifers or cows. Where such a course is possible it is in the writer's opinion the best method of maintaining a herd because of the possibility of improvement in milk yield and breed type from year to year, but this improvement will only be gained if great care is given to the choice of a stock bull. In breeding herds, therefore, one of the chief practical aims is the selection and purchase of a bull with a view to the breeding of heifers of greater milking capacity and of better type than their dams.

In the selection of heifers and cows for the commencement or maintenance of a herd, attention should be directed chiefly to the age, type, breeding (including if possible the milk records of the parents), and place of origin. Many dairy farmers

prefer always to purchase first-calf heifers and this course has much to recommend it, because heifers purchased at or soon after calving give an immediate return for their keep, are usually healthier than older cows, and, should they prove unsatisfactory as milkers, they can be disposed of at a price which shows little or no depreciation on their original cost. The quantity of milk produced by a herd of first-calf heifers is not equal to that produced by a herd of mature cows, but the greater risk of a considerable depreciation in the value of the latter usually turns the scale in favour of the younger animals. Where second-calf cows can be purchased from a healthy herd, they may be preferred to first-calf heifers because they will give larger yields, and the shape and size of the udder and position of the teats can be seen better.

Milk recording has made great progress in recent years, but as yet records are not available in respect of dams and grand dams of the great majority of the heifers available for purchase, hence, purchasers must depend on selection by external characteristics—conformity to breed type, size, constitution and healthiness and potential milking capacity as denoted by udder and milk vein development. In this connection it is interesting to note that one of the American Agricultural Experiment Stations has recently published the results of a comprehensive study of the relative importance of the different milk yield "indicators" in the Jersey breed. The degree of correlation between the actual yield, as shown by lactation records, and conformation of different parts of the body as measured by the marks awarded on a score card basis, was found to be surprisingly wide ; the most reliable indicators were found to be : (1) the milk veins, which should be large, tortuous, and elastic ; (2) the hindquarters of the udder, which should be well rounded and well out and up behind ; (3) the udder, which should be of large size and not fleshy ; and (4) the body, which should be wedge-shaped with deep large paunch, legs proportionate to size and of fine quality. The same investigators, however, point out that the actual yield of milk as found in a seven-day period a few weeks after calving is twice as accurate an indication of the cow's ability to produce milk as any external features or "points" of the animal.

It is highly probable that these conclusions are also largely applicable to other breeds, and the value of milk records in the sale and purchase of dairy cattle is thus confirmed from another point of view. The purchaser of dairy stock is therefore less likely to be disappointed in his purchases if he selects stock privately from milk-recorded herds or from complete dispersal sales of such herds. He must, however, study the published records closely, remembering that information as to the milk yields, number of days in milk, and dates of calving for two or three successive years are much more reliable basis for judgment than the yield for one year or lactation period only.

To the owner of an established dairy herd, the selection of a young bull is one of the most important practical points. The only true means of improvement of a herd is by breeding, and the test of improvement is that the home-bred heifers should

be better animals and better milkers than their dams ; the chief agent in this improvement must therefore be the bull. If we assume that the dairy farmer on the look out for a young bull can be relied on to make a good selection on the basis of external appearance according to the points of the favoured breed, there are at least two other points which should be studied. The first is the dairy characteristics of the bull's dam and, if possible, his grand dams ; these cows should be of good breed type, healthy and with well-developed shapely udders and teats. The second point is the milk records of the dam and grand dams ; these should be studied in detail as specified above in regard to the records of cows, remembering that an average of, say, 9,000 lb. over three successive years is a more valuable indication of constitution and milking properties than a one year's yield of 11,000 lb. to 12,000 lb. A third point which should be studied in some instances is the percentage of fat in the milk of the dam and grand dams. On this point there will most probably be little or no information obtainable, but nevertheless there are good reasons why intending purchasers should persist in asking questions on this point. It is well known that as a rule (though fortunately there are occasional exceptions) heavy milking cows yield milk of less than average quality, hence the continued selection of bulls on the basis of milk yield only will tend to lower the average quality of the milk produced by the herd and increase the risk of trouble with the local authorities responsible for the administration of the Food and Drugs Acts. To many dairy farmers the main object is to get an increased yield from their herd, and if the use of a bull, the son of a heavy-yielding dam whose milk averaged only 3 per cent. of fat, would ensure an increase of 100 to 200 gallons per cow, they would take the bull and risk any trouble in respect of quality. There are, however, many others who have already high herd averages, and in such cases the quality of the milk should receive attention ; buyers of milk are likely to have an increasingly wide field of producers to select from, and discrimination may be exercised to the disadvantage of those whose milk is troublesome in respect of quality.

Management of the Dairy Herd.

A dairy herd is kept for the purpose of producing milk, hence the management should include all those details which experience and research have shown to be advantageous and economical. Milk recording has proved its value in hundreds of cases as a means of improving the average yield and thus giving a larger sale of milk from the same number of cows with the same expenditure on labour and other overhead charges. Butter-fat testing in herds where the milk is made into butter or cheese has also shown how the output from the herd can be increased ; where young bulls are sold for stock purposes, information as to the fat percentage in the milk of the dam may enable a higher price to be obtained. Service and calving records should be carefully kept to enable cows to be dried off in preparation for the following actation period, and times of service should be regulated so that cows will calve at

the time when the maximum production of milk is most desirable or when it is most profitable.

All cows should be marked by tattooing or some other method so that they can be identified, and all calves reared for stock purposes should be similarly marked and a record kept of the tattoo number or markings so that they may be identified and their ancestry traced when necessary. Failure to mark calves so that they can be identified later has caused numerous herd owners to lose many years in the grading-up of stock for registration in the Breed Herd Book. Milk Recording Societies, operating under the regulations of the Ministry of Agriculture, now undertake the tattooing of calves and keep the necessary records, and membership of one of these societies affords the easiest and most reliable means whereby records of milk yields, butter-fat percentages, calving and service dates and the tattoo numbers of cows and young stock can be obtained. The cost of membership is not great and, though the farmer must at present consider carefully every item of expenditure, the money spent on milk recording and calf marking should be looked on as a good investment, for there is no doubt that in the course of time it will return a highly satisfactory rate of interest.

Another important aspect of herd management is the maintenance of a thoroughly healthy dairy herd free from contagious abortion and tuberculosis, and with the minimum of udder troubles. Probably the most effective precaution which can be taken to prevent outbreaks of contagious abortion is to rear sufficient young stock to maintain the herd, thus making purchase of female stock unnecessary, and to keep a bull for the herd. The same procedure is also very desirable when a tubercle-free herd has been obtained through the application of the tuberculin tests and elimination of reacting animals. In spite of the criticism still occasionally directed against the tuberculin tests there is a steady increase in the number of practical dairy farmers who are convinced that the application of the tests and action according to the results obtained is well worth while, because in addition to freedom from tuberculosis, herds of non-reacting animals are healthier in every other respect. With regard to udder troubles the chief precautions are close observation, immediate treatment of every affected quarter according to the nature of the trouble, isolation of the cow when necessary and particular attention to cleanliness in housing and milking.

In all matters affecting the health of a herd the advice and assistance of a veterinary surgeon should be sought without hesitation, and there can be no doubt that the circumstances are most favourable to successful treatment in herds of home-bred stock (where the life-history of each animal is known), housed, fed, watered, and milked under cleanly conditions.

Organization of Labour.

On many farms the wages bill is the largest single item in the annual expenditure. The first essential is to get one or more good men who understand the work

of herd management and of land cultivation, and who are not afraid of responsibility. A good herdsman or head cowman is well worth good wages ; if his duties and responsibilities be considered in detail it is at once realized that no expenditure by the owner of time and money in the selection and breeding or purchase of valuable dairy stock, or in the provision of model equipment can ensure success without the whole-hearted co-operation of the men who feed, milk and attend to cows at calving time, deal with cases of udder trouble and the numerous other small but nevertheless important items in the management of a dairy herd.

The only school from which such men can be obtained is that of experience, and although occasionally it may be imperative to make a change in order to get a more reliable staff, as a rule the problem before each farmer is to consider what steps he can take to arouse a greater and more intelligent interest in their work on the part of the men he already employs.

Assuming that the farmer himself is keenly interested in the welfare of his herd and in all details of herd management, there are a variety of ways in which the interest of the men may be developed. The bonus system may be introduced in some suitable form and additional payments made on the basis of the number of calves born, or the number of cows attaining yields of 10,000lb. of milk per annum or lactation period, or on the total output of milk. There are objections, however, to giving a bonus in connection with the usual duties of the cowmen or milkers. A good man should not and does not require special payment as an inducement to give a calving cow special attention, and where bonuses have been paid on a milk yield basis instances have been known of the records having been inflated. At the same time the bonus system may be most helpful in some instances, for example, in the production of graded milk, where the amount of the bonus can be made dependent on the bacterial count. Success in clean milk production depends primarily on the manner in which the routine work of washing and sterilizing utensils, cleaning cows and milking is carried out, and as the degree of efficiency in this work is determined by the bacteriological content of the milk, a bonus payable on such a basis is only paid when there is independent evidence that a high standard of work has been attained.

The introduction and development of milk recording has done much to improve herd management and to make the twice daily task of milking more interesting. The daily or weekly weighing of the milk institutes a measure of progress and a basis of comparison which was previously lacking, and on many occasions the writer, when doing milk recording work, has been struck with the interest shown by the milkers in the yields of different cows. Any suggestion which might mean an addition to the number of milk recording forms issued under the Ministry of Agriculture's scheme can only be made with great reluctance but nevertheless a card, which should be kept in the cowshed, so ruled as to show the amount given each week and the total to date for each cow in the herd would be a handy record for the owner and would be greatly appreciated by the men. In many cases the milker knows the highest

daily yields of the cows he milks, but is never informed of the total yield in a year or lactation period.

In respect of feeding much can be done by the farmer in selecting the kinds and quantities of foods which will give a suitably balanced ration, and in a system of feeding in relation to milk yield, but the giving of the allowances of concentrates, etc., at each meal must be left to the cowman, and in the case of heavy milking cows there are times when it is most important to have a man who knows when to depart from the usual system ; in other words, the man who actually feeds the cows has as much need for knowledge of the composition and effects of the different foods as the man who grows and buys them. Much can be done towards supplying this knowledge by distributing the Ministry's leaflets and Agricultural College bulletins on foods and feeding, but attendance at a lecture or course of lectures is much to be preferred. On several occasions when arranging the time of a lecture on the feeding of dairy cows, the writer has been asked to agree to an hour which would permit of the attendance of the cowmen as well as farmers, and such meetings have invariably been well attended and followed by acute and interesting discussions. There is room for a wide development of this principle. The great majority of herdsmen and milkers are truly interested in their work, and a more extensive co-operation between the farmer and the county agricultural education authorities with a view to providing short courses of instruction in dairying districts on such subjects as rationing of dairy cows, secretion of milk and milking, cleaner milk production and first-aid treatment in common diseases, particularly of the udder, will be very much appreciated and cannot fail to give the men a more intelligent understanding of their work and ensure better management of the dairy herd.

Management in relation to Sale.

Milk. The chief product which the dairy farmer has for sale is milk, and the method of sale is to a great extent governed by the position of the farm in relation to a market. Where the farm is situated close to a large centre of population there are two alternatives : (*a*) to sell by retail direct to the consumer ; (*b*) to sell wholesale to a retailer. Where the former method is adopted the farmer gets a higher price because he undertakes the work of distribution as well as that of production, and should get a profit on both branches. On the other hand the distribution of milk direct to the consumer's house requires great attention to detail, and may well be quite as worrying as the management of a herd of dairy cows. Provided that the farm is in a suitable position for the development of a retail business, it may well be that the deciding factor is the temperament of the farmer himself. To many it is sufficient to undertake the production side of the industry, and be content with the producer's profit ; to others, including those in whom the business instinct is more highly developed, the probable extra profit is a deciding factor, and they undertake the labour and worry of the distribution side of the business in order to obtain this extra return.

Where the farmer is also a retailer he should make a study of the practical details of this business, including the organization of delivery rounds to save as much labour as possible, the handling of milk to ensure uniform quality, the best mode of delivery—whether from a churn or by can or bottle—and the washing and sterilization of all utensils to avoid the delivery of milk which will sour quickly. In addition he must master the art of maintaining good relations with his customers, and be ever on the look-out for new ones. If the supervision of these details cannot be undertaken by the farmer himself he must employ an efficient manager who will be able to hold his own in competition with the man who is a retailer only and who is therefore able to devote his whole time to this work.

Generally, however, the dairy farmer is not a retailer of his own produce ; he sells his milk wholesale because the distance of his farm from a market leaves him no other practical alternative, or he makes it into cheese or butter on the farm. The price he receives is of paramount importance, but he has also responsibilities in the milking of the cows and handling of the milk, and the manner in which this work is done has a direct bearing on the trade value of the milk itself. No one will contend that milk which goes sour within twelve or twenty-four hours is worth as much either to the distributor or the consumer as milk which will keep sweet for forty-eight hours or more, and it is therefore the business of the farmer to take all practicable precautions to produce a wholesome and good-keeping milk. The distributor and the householder must share the responsibility for the condition of milk up to the time it is used, but undoubtedly the farmer must take the first steps, which consist in seeing that the cows are cleaned before milking, that the utensils through which the milk passes are clean and sterile, that the milking is done in a cleanly manner, and that the milk is immediately cooled to as low a temperature as possible and kept cool and protected from heat and dust before and, if delivered by the farmer, during conveyance from the farm. Much study has been devoted to the handling of milk on the farm in recent years[1] with a view to discovering the simplest and most effective methods, and the latest information is easily obtainable on application to the agricultural educational authorities in each county, or the nearest agricultural school or college.

With regard to price, often there is little that the individual farmer can do to obtain a higher figure. The distribution of milk covers such a large series of operations from the farm to the consumer, and the quantity to be dealt with is so immense and yet so fluctuating, that large wholesale or retail organizations have grown up to undertake this phase of the business, and as these farms have also to deal with the seasonal surplus milk they are in a very strong position when negotiating on prices with a single farmer. The only way in which a farmer can hold his own is by co-operating with other farmers who also have milk to sell, and much has been done in this direction by the National Farmers' Union. The scheme of prices and

[1] *Min. Agri. London, Mis. Pubn.* No. 41.

quantities agreed on by the Committee composed of representatives of this Union and of all the distributors' organizations has proved quite workable and has helped greatly to stabilize the industry during the last two years.

Farmers must always remember, however, that the distributive or manufacturing sections of the industry will not purchase more milk than they can dispose of at a profit, taking one year with another, and that the fixing of a price by agreement for the country as a whole with modifications according to areas, does not necessarily mean that there is a market for every individual farmer's milk. Milk production is undoubtedly increasing throughout the country : the purchase and use of milk by the public must also increase, otherwise many producers may find that milk of the cleanliness and keeping quality which they produce cannot find a profitable market. It would appear, therefore, that it should be part of the practical farmer's policy to do all he can to increase the consumption and use of milk, and to take great care that the milk he himself produces is such that the purchaser will wish to drink and use more of it.

There is also the possibility of producing a higher grade milk which will command a higher price. Since 1915 licences to describe milk by special designations have been obtainable from the Ministry of Food, and later from the Ministry of Health, and the possessors of these licences have as a rule obtained a higher price for their milk. The question at once arises, " Is the increase in price sufficient to meet the increase in cost of production involved in complying with the regulations under which such licences are granted ?" In many instances the answer is undoubtedly—Yes. There is also an increasing amount of evidence that where, in order to obtain a Grade A (Tuberculin Tested) Licence, or a Certified Licence, an owner has eliminated all cows and heifers in milk which react to the tuberculin tests, the standard of health is definitely raised in the herd as a whole and losses are materially lessened.

Cheese and butter. Where the milk is made into cheese on the farm, the sale of the cheese is in the hands of the farmer. The price obtainable for English hard-pressed cheese is, however, influenced by the price of imported cheese, and where the home-made product is of second class or inferior quality it is increasingly subject to very keen competition. The choicest qualities of the well known English varieties have always commanded good prices, and will continue to do so ; it appears obvious, therefore, that the farmer who makes cheese should do all he can to maintain and improve the quality of his product and also join with others interested in this branch of the industry in making known to the public the merits of English cheese, so as to increase the demand. It must, however, be recognized that advertisement will do more harm than good, unless the high quality and uniformity of the product can be assured.

In respect of butter, it is estimated that 32 per cent. of the milk produced in Great Britain is used for butter making, but there is no doubt that in many districts this

course is followed in order that the separated milk may be available for the raising of stock, rather than for the direct returns received from the sale of the butter. Numerous private dairies make butter of the highest quality which is disposed of at a satisfactory price, but farm butter as a whole is so varied in colour, flavour and keeping qualities that it cannot have more than a local market. Where the quantity of milk to be made into butter is sufficient to provide a regular supply winter and summer, and no other outlet for the milk is available, then every effort should be made to produce butter of the best quality and to find a market amongst those who are prepared to pay an adequate price for a first-class home product.

Surplus Stock.

Little can be written which will help farmers in the sale of animals which are depreciating in value, and there are usually a few such in every dairy herd. On many farms where a breeding dairy herd is kept, however, it may well be worth while to rear a large proportion of the heifer calves, partly in order to have a larger number to select from for maintaining the herd and partly because there is usually a good demand for dairy heifers, either when fit for service or down calving. Surplus stock of this sort may be a valuable source of income, and if the milk records of the dam and sire's dam are good enough to be published, then the market price of good animals is further enhanced. There is also a steady demand for in-calf heifers and young cows which have passed the tuberculin test, and when animals of the right type and breeding are to be sold, their market value will be increased if they are offered for sale with certificates that they have passed the tuberculin tests required by the Ministry of Health for entry into Grade A (Tuberculin Tested) and Certified Herds.

Conclusion.

The chief practical aim of the dairy farmer was defined at the commencement of this article as the obtaining of the largest average net profit over a period of years. It was pointed out that this end can only be attained by good-all-round management in respect of purchases and sales, in utilization of the land and other raw materials for production, and in the organization of labour. Many points in such management have been discussed in detail above. It is now only necessary to emphasize that this does not mean a conservative stay-at-home policy. Interest, enthusiasm and personal attention to principles and occasionally some details on the part of the farmer himself are essential to good management, but it is also desirable that the farmer should take a judicious share in the farming activities of his district and in the work of the local Agricultural Society and the County Milk Recording Society; he should also visit experimental farms and well-managed farms in other districts to see the methods which have brought success or failure there. In times like the present old methods must be reconsidered, new methods and suggestions studied and perhaps given a trial, and an open and inquiring mind must be joined with a determination to succeed.

NOTES.

RAISING DAIRY CALVES FOR HIGHER PRODUCTION.

How to increase the low production of milk in India is a very great problem before the dairymen of India. Not many of the average farmers know the principles and methods of raising heifer calves for a higher production. If we compare the average production of our cows with the production of the cows in the United States of America or other countries on the globe, we will be looking with surprise. Now, just for an example, the Nebraska College of Agriculture (U. S. A.) has developed a number of cows that have produced at least 22,000 lb. of milk and over 1,000 lb. of butter-fat per year. What makes it possible ? There are two answers for this question. The first is, use better and pure-bred herd sires, in the second place raise only the best heifer calves.

Now the question that may arise is how to raise the calves, and know if they are the best or not. In order to select the most desirable calves, it is essential that production records be kept for each cow in the herd. These records should include the amount of milk and butter-fat produced and the amount and cost of feed consumed during the calendar year. Fairly accurate records may be obtained by weighing the feed and milk during one day of each month and by testing a sample of milk from both milkings of that day for butter-fat by the Babcock test.

Should you raise twin calves ? Yes, if both the calves are of the same sex ; if not, the female is usually sterile. It is a proven fact that it is not profitable to raise twin calves for dairy purposes.

You should separate the calves from their dams within 20 or 24 hours of birth. In case of very high producing cows, remove the calves within twelve hours, otherwise there is always danger of scouring.

If the calf is not able to drink, that is, does not know how to drink, then do not feed it anything, let it get hungry. Hunger alone will teach it how to drink. Feed a small quantity of the mother's milk at as nearly body temperature as possible. Patience and perseverance are necessary in teaching a calf to drink. One way of teaching the calf to drink is to moisten your fingers and let it suck. A few minutes later remove your fingers from its mouth. Do not force the calf's head in the pail and hold it there, for it will choke the calf.

Feeding whole Milk.

Whole milk is the natural feed for young calves and contains all the elements necessary for their growth. If you want to be a successful calf raiser, then feed the calves whole milk until they are able to get nourishment from some other feeds.

This will show that it is necessary to feed whole milk until the calves are about three or four weeks old.

It is a good plan to feed the calf milk from its own dam for three or four days. Later feed mixed milk of the herd. The amount of milk fed varies according to the weight of the calf; about 1 lb. of milk to each 10 lb. of live-weight is sufficient. If you feed the calf three times a day, then feed a little more milk, but be careful not to overfeed. At the end of the period of three weeks, if skim milk is not available, feed a small amount of whole milk supplemented by grain and hay. About 1 lb. of milk for each 8 lb. of live-weight is sufficient until the calf is 4 or 5 weeks old. At that time, if the calves are consuming a good amount of grain and ration, the milk may be reduced at the rate of 1 lb. per day at the beginning of each week.

When the amount of milk is reduced, replace the amount with warm water. It is necessary to feed sufficient milk in order to keep the calves in good growing condition. Generally the amount fed to a calf should never be less than 450 lb.

Feeding skim Milk.

Skim milk is the most satisfactory supplement to whole milk for calf feeding. Calves fed skim milk do not become as fat as those raised on whole milk; they make a vigorous, sturdy growth of body and frame. It is not absolutely necessary to feed some high protein feed when whole milk is replaced by skim milk.

Skim milk may be gradually substituted for whole milk as soon as the calf is able to get some of its nourishment from hay and grain. It is advisable to teach the calf to eat some legume hay at an earlier age, because the leaves of these plants contain growth-promoting elements similar to those found in butter-fat. The amount of skim milk to be fed is determined in the same manner as suggested for whole milk.

If calves over 6 weeks old are fed sour milk, they show good results. To feed it successfully care must be taken that the milk is freshly soured and is not several days old. It is absolutely necessary that the temperature of the sour milk fed should be uniform at all times.

A suitable Grain Mixture.

Grain is a cheaper feed than whole milk. Calves less than a month old will eat grain more readily if it is finely ground, but older calves like coarser feeds. Calves under three months old will usually not overeat if fed grain from a self-feeder. Older calves should be fed grain in limited amounts, 3 to 4 lb. daily being sufficient for calves 3 to 6 months old.

A good grade of fine stemmed legume hay should be kept in a feed rack where the calves have access to it. As soon as the leaves and finer portion of the hay have been eaten, the remainder should be removed and fed to other animals in the herd and a fresh supply substituted. When calves are three to four weeks old they will begin to eat hay in some quantity.

Success in raising calves depends upon the caretaker. Regularity and attention to the details in the feeding and care of dairy calves are very essential because the character of the growth obtained measures the value of the animal when mature.

Warm, comfortable quarters are just as necessary as correct feeding. Calves must be protected from cold drafts and dampness, supplied with fresh air and allowed to exercise.

Fresh water should be supplied to the calves over a month old. A small amount of salt should be given to the calves two to three months old. A little salt may be sprinkled in the feed trough or it may be kept in a box to which the calves have access whenever they desire.

Cleanliness is absolutely necessary. Pails, feed troughs, and racks from which the calves are fed, and the pens, yards and the calves themselves should be kept clean at all the times. Feed must be in good condition and utensils must be kept in sanitary condition if the health of the calves is to be protected. Clean, comfortable pens supplied with plenty of dry bedding are one of the best preventives of disease. [YESHWANTRAO P. BHOSALE.]

MANUFACTURE OF SUGAR DIRECT FROM CANE IN INDIA.

TWENTY-THREE factories making sugar direct from cane worked in India during the season 1923-24 as compared with 19 in the season 1922-23 and 18 in 1921-22. Eleven* of these factories are situated in the province of Bihar and Orissa, 8 in the United Provinces of Agra and Oudh, 2 in Madras and one each in Assam and Bombay. Enquiries were instituted by the Sugar Bureau to ascertain the output of these factories, and we are much indebted to the management of these factories for their courtesy in furnishing the statistics required under various heads.

The table below shows the total amount of cane crushed and sugar made by the factories in (1) Bihar and Orissa, (2) United Provinces and (3) other provinces of India. The production of sugar direct from cane by modern factories in India totalled 1,044,855 maunds or 38,312 tons during the season 1923-24 as compared with 651,415 maunds or 23,886 tons in the season 1922-23.

Provinces	Cane crushed in maunds		Sugar made in maunds		No. of factories working	
	1922-1923	1923-1924	1922-1923	1923-1924	1922-1923	1923-1924
Bihar and Orissa . .	4,770,721	6,738,391	377,292	509,547½	9	11
United Provinces of Agra and Oudh.	2,461,397	5,258,728	171,272	368,790½	6	8
Other Provinces of India .	1,423,256	1,996,917	102,851	166,517	4	4
TOTAL FOR INDIA .	8,655,374	13,994,036	651,415	1,044,855	19	23

*One factory in Bihar did not furnish the required figures.

A study of the statistics will show that there was an increase of 5,338,662 maunds in the quantity of cane crushed and of 393,440 maunds in the amount of sugar produced by factories in India during the season 1923-24 as compared with 1922-23. This increase in all the provinces was due mainly to the fact that factories could obtain more cane for milling in the season 1923-24. It may be mentioned here that, in the season 1923-24, the area under sugarcane in India was 169,800 acres greater than in the previous season.

If we take the all-India figures we find that 13·39 maunds of sugarcane were required in the season 1923-24 to produce one maund of sugar as compared with 13·28 maunds required in the previous season. This was due to the fact that some of the factories in the United Provinces were so overwhelmed with cane that they had to put it through the mills much faster than usual in order to take off this crop.

During the season 1923-24, India's production of molasses by modern factories making sugar direct from cane totalled 622,473 maunds as against 348,024 maunds in the previous season. The increased production should naturally result in a reduction to that extent of the imports of foreign molasses into India unless consumption shows an increase in this country.

Statistics regarding the production of refined sugar by modern refineries in India are being collected and will be published in due course. [WYNNE SAYER.]

REFINING OF INDIAN *GUR*.

IN the Report of the Indian Sugar Committee of 1920 we read that "*gur*, *gul* or *jaggery* is cane juice concentrated to solidification without purification, except the addition of a small amount of alkali and the removal of scums. In India, 99 per cent. of the sugar made is *gur*."

Since the sugar production in India is more than three million tons per annum, the above statement means that, even to-day, nearly one quarter ($23\frac{1}{2}$ per cent.) of the total cane sugar production of the world is obtained in the crudest possible form. All of this *gur* is of course consumed locally, and mostly in the crude form in which it is originally produced, but a certain—and increasing—amount is refined in order to obtain a higher grade sugar.* The conditions in India are not generally favourable to the operation of large factories producing a high-grade white sugar direct from the cane, and it appears to be very probable that *gur* refineries will be fully as important as sugar factories during the next decade. Moreover, since *gur* will keep, the sugar factories, with the addition of a comparatively small amount of machinery, can be used for *gur* refining during the off-season.

* For 1922-23, about 3 per cent. of the *gur* produced in India was treated in the *gur* refineries, the output of sugar from this source being more than double that from the cane factories.

Although a certain amount of acclimatized tropical cane is grown in India, practically the whole of the cane *gur* is produced from the indigenous Indian canes ; owing to the great variety of these, and the crude and varying local methods of production, the composition of *gur* is exceedingly variable, which adds very considerably to the difficulty of treating it in a *gur* refinery.

In general, the sucrose content is fairly high, but it is accompanied by an excessive proportion of glucose, organic impurities, and ash, so that the purity is low, and it is by no means a simple matter to produce a high-grade sugar direct from *gur*, on a commercial scale. As the *gur* is made in direct-fired pans, burned or caramelized *gur* is not at all infrequent, and this adds considerably to the difficulty of refining.

In addition to the *gur* from cane juice, there is an actually large, although relatively small, amount of *jaggery* produced from the liquor tapped from certain date palms, and this is usually even more troublesome to refine than is the *gur* from the indigenous sugarcane.

The quality and condition of *gur* vary to such an enormous extent that definite estimations are quite impossible, and a refinery designed nominally to deal with a certain amount of *gur* may actually deal with 50 per cent. less or more—the former being the usual experience.

Most of the existing *gur* refineries have been built up gradually ; there is usually but little technical control, and technical information on the subject is conspicuous by its absence ; even *gur* analyses are not readily available, and are usually very incomplete.

A consideration of over 20 analyses of *gur* from different parts of India shows that the sucrose content varies from 62 to 87 per cent.; the glucose from 5 to 20 per cent.; the moisture from 5 to 15 per cent.; and ash up to 6 per cent. or even more. As the result of a careful study of available data from various sources, the writer considers that a fair average analysis of *gur* is :—

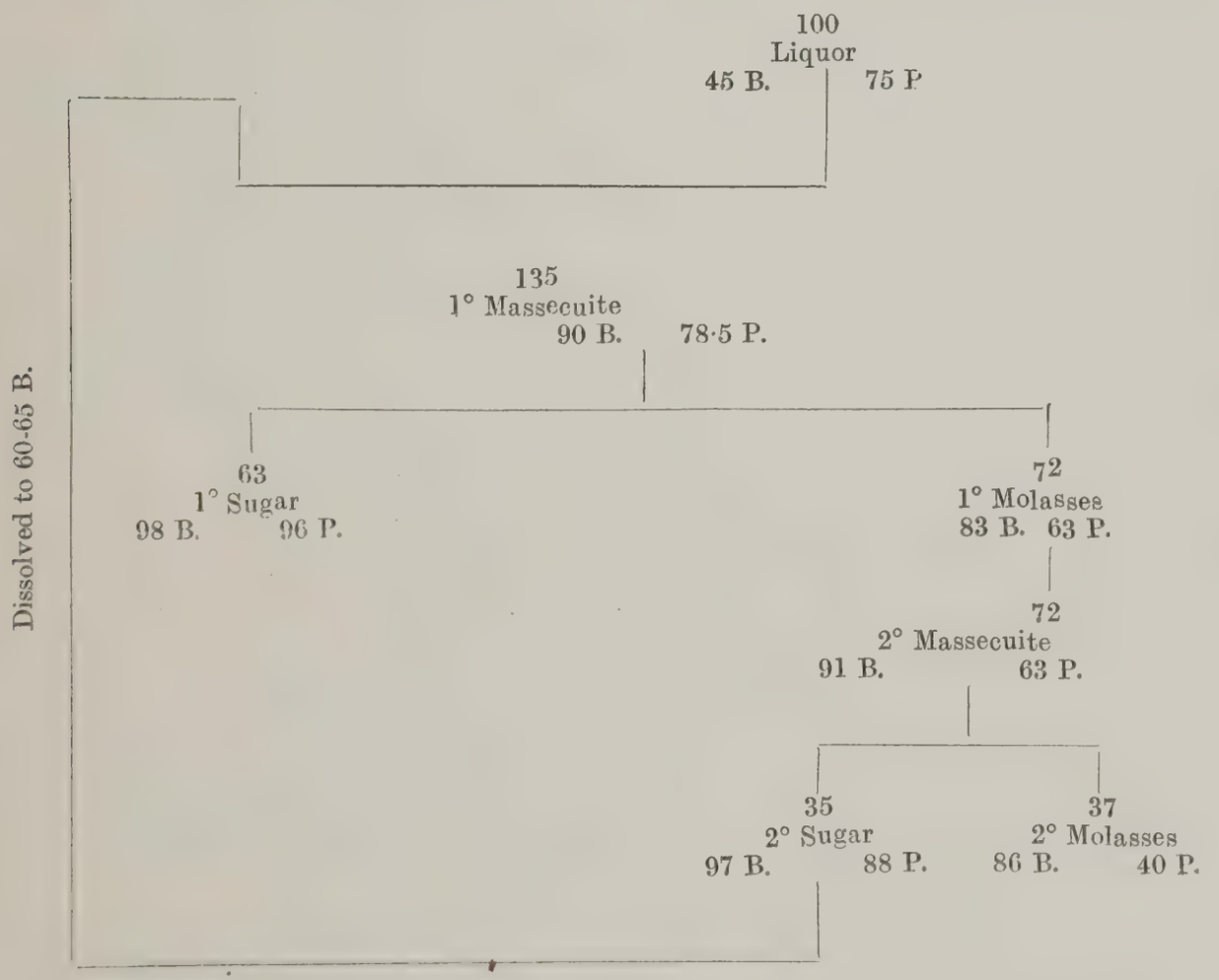
	Per cent.
Sucrose	67
Glucose	15
Other soluble organic matter	8
Water and insoluble matter	10
TOTAL	100

so that approximately, the average *gur* may be taken as 90° Brix. (per cent. solids) of 75 per cent. purity and 22 glucose ratio. As before mentioned, the variations in practice are very great indeed, but the above figures appear to give a reasonable average.

The simplest method of *gur* refining is of course merely to dissolve, clarify with lime and heat, filter to remove the mechanical impurities, crystallize *in vacuo*, and

separate the crystals in a centrifugal, the result being roughly equivalent to the second sugars obtained in an ordinary defecation factory, which is all that can be expected from a simple treatment, since the dissolved *gur* is usually but little better than an ordinary first molasses. For a rough approximation, 100 lb. of *gur* of the average composition mentioned above, when treated in this simple manner, may be expected to give about 45 lb. of sugar of 94° purity,* and 55 lb. of molasses of 55° purity, which would be marketed as such.

Much of the colouring matter may be bleached by a single sulphuring, giving a higher grade of sugar. The molasses may be boiled for a second sugar, which is redissolved and returned to the liquor, as indicated by the accompanying diagram ; in this case we may expect to obtain roughly 56 lb. sugar of 96° purity† and 40 lb.



B = Brix. P = Purity. Quantities refer to solids.

molasses of 40° purity from 100 lb. of *gur*. In some cases, depending on the composition of the liquors and the plant capacity available, the exhaustion may be made in

* 42-43 per cent. is the usual recovery, of perhaps a slightly higher purity.

† The usual recovery is from 52-53 per cent. in Northern India to 57-58 per cent. in Southern India.

three stages, the third massecuite being boiled high, left in concrete tanks for a few weeks, pugged and centrifugalled and finally re-dissolved and returned to process.

The 96° sugars may be raised in purity by washing in the centrifugals, or by double curing, with, of course, a corresponding amount of dissolved solids returned to process for further refining. With the higher grade *gurs*, a satisfactory sugar of 98-99° purity can thus be obtained, which will be nearly white providing proper attention has been given to the sulphuring. With the lower grade *gurs*, and especially those from date-palm juices, if a 99° purity white sugar is required, practically the only method is first to recover as much sugar as possible at something over 90° purity, with a preliminary sulphuring of the liquor ; then to re-dissolve, lime and sulphur to whiteness, filter, re-crystallize, etc., as best white sugar.

For the highest grade of refined white sugar, the liquor is, of course, filtered through bonechar, but in India the laws of caste generally preclude the use of this process for sugar intended for consumption by Indians, so that the sulphitation process is usual. India would appear to offer a favourable field for the use of vegetable carbon for decolorizing purposes, if the cost can be brought down to compare with that of sulphitation.

In many parts of India, a white sugar, finely pulverized, is very highly esteemed ; and when this is to be made, the size of the grain formed in the vacuum pans is not of vital importance, so long as it is large enough to be retained by the centrifugal gauze. Even with the fine powder, uniformity of size of the particles is of importance ; the sugar must be properly dried, and then pulverized in high grade 4-roller pulverizers, with accurately ground rollers and micrometer adjustments, exactly similar to those used for flour milling. [P. H. Parr in *Int. Sugar Jour.*, Vol. XXVI, p. 532.]

THE CONTROL OF THE COTTON WEEVIL.

Find what it is in the cotton plant that the boll weevil likes ; produce it in marketable quantities ; bait traps with it or mix it with poison, and so lure the insects to their destruction. That is the skeleton of the idea on which scientists of the U. S. Department of Agriculture are working.

When the weevil comes out of its winter sleep, in the vicinity of a cotton-field, it somehow knows enough to make a bee-line for its natural home. It will sometimes travel considerable distances to reach growing cotton if there are no plants near at hand.

Dr. Frederick B. Power, the leading biochemist in the Bureau of Chemistry, with the co-operation of V. K. Chesnut, of the same bureau, is endeavouring to find which of the many complex substances in the cotton plant gives it this peculiar attraction for the weevil and this is a very difficult task. Large quantities of cotton plants have

been subjected to steam and distillation processes, and the substances isolated tested for their power of attracting boll weevils. This part of the work falls to the Bureau of Entomology, where workers watch the behaviour of the insects toward the various substances.

Dr. Power states, with the characteristic caution of a thorough scientist, that he is "making progress," but will not make a direct claim that the problem has been solved. The results of the investigation will be announced to the scientific world and to the public in due time.

This new attack on the boll-weevil problem may well become the pioneer work in a wholly new departure in the study of the relations between plants and the enemies that attack them. There are many other insects that show a similar preference in the choice of the plants they feed on. Potato beetles, for instance, confine their diet chiefly to potato plants ; the Hessian fly commonly attacks nothing but two or three kinds of grain. In all such cases, there must be some definite attraction exerted by the plant, some specific substance that appeals to the insect so strongly that it will turn from all other things to seek it. If such substances can be isolated and used as baits loaded with poison, or placed in insect traps, or set over pans of water or oil, or in other ways utilized to lure insect pests to their doom, another step will have been taken in the solution of the crop pest problem. [*Science*, N. S., Vol. LX, No. 1554.]

DEVELOPMENT OF MANLESS PLOUGHS.

Reading that is almost fascinating in its interest is contained in a paper that was contributed, says Chicago *Farm Implement News*, at a meeting of the American Society of Agricultural Engineers, and in which mention was made of the fact that two agricultural engineering students in the United States had built ploughs of the "manless" type. One of the manless ploughs consisted of a two-wheel tractor with a four-h.p. single-cylinder engine to provide the power. Right and left hand plough breasts were attached to the frame, had their beams opposite and nearly at right angles to the tractor axle, and were so placed that while one was in work the other was carried above the ground surface. In operation the outfit was steered by hand for the initial furrow, after which the first furrow served as a guide for the plough. The success of the plan was fully demonstrated, for a driving wheel will only rarely leave a furrow wall and the furrow does not need to be particularly deep to control a plough in this manner. The machine travelled back and forward in the shuttle style. A reversing arm or antenna hung over the tractor and extended out some distance beyond the machine in each direction. This reversing arm, upon coming in contact with a fence or other obstruction, was pushed back to a point where spring action came into place and reversed the direction of the driving mechanism. The reaction immediately lifted the breast in work out of the

ground and swung in the other one, a proceeding that took place quite smoothly and positively. One problem in connection with the operation of the machine was that of moving the tractor over across the direction of travel the width of one furrow each time the machine was reversed. This was secured by causing the driving wheel on the ploughed ground side of the tractor to make a part of a revolution with the driver on the unploughed part acting as a pivot. It was found that to put a machine of this kind into actual service some safety devices would be necessary, such as making provision for the stopping of the engine should the plough leave the furrow. The inventor has worked out a simple means of doing this.

The second manless plough was the result of the study of a machine with a stationary motor using cables. This machine consisted of a skid carrying an electric motor and reels for the main cable used in drawing the implement to and fro across a field, an anchor skid upon the opposite side of the field carrying a pulley, reels on the motor skid for moving the power skid and anchor skid forward at the precise time, reversing mechanism to the motor and intermittent drive to the reels for moving the skids. The mechanism for moving the power and anchor skids was one of the most ingenious parts of the machine. This device moved the skids alternately every time the motor was reversed by taking in cables attached to the anchor at the corners of the fields. The skids were held in place by one runner following a furrow. It is suggested that when such an outfit has been thoroughly tried out and perfected there is no reason why it should not work continually for a 24-hour day.

THE WORLD'S WHEAT SUPPLIES AND REQUIREMENTS.

The following survey of the position as regards the world's available supplies and requirements of wheat has been published by the International Institute of Agriculture in its October International Crop Report.

Exportable Surplus.

The quantity of wheat which, in theory, was exportable from the five chief exporting countries at the beginning of August, may be estimated at 122½ million centals* from Canada, 148 million from United States, 23½ million from India, 25 million from Argentina, and 7 million centals from Australia, thus aggregating about 326 million centals.

Exportable surpluses probably existed at 1st August 1924 in other countries, particularly in Balkan lands, in Hungary, Manchuria, Chile, and Uruguay. No basis for estimating the quantities available in these countries is discoverable, so that only a rough estimate is possible, which would place the aggregate figure of

* 1 cental = 100 lb.

exportable stocks in these countries at 18 million centals on 1st August, 1924. Russia exported some millions of centals of wheat last year, but can scarcely be expected to do much this season in view of the deficient crops in that country. In favourable seasons Algeria and Tunis take their place amongst exporters, but this year's poor crops may constrain them to import wheat.

To sum up, the quantity available for export at 1st August may be taken at about 344 million centals. At the beginning of 1925 this quantity will be reinforced by the exportable surpluses from the new crops of Argentina and Australia, now well advanced in growth. According to the most recent advices, prospects are satisfactory in both these countries, so that, taking into account the slightly increased areas sown in each of them, it may be expected that their aggregate yield will not fall below that reaped last year, which amounted to about 220 million centals. Inasmuch as their aggregate consumption is about 70 million centals, it may be hoped that the quantity of wheat harvested in Argentina and Australia will allow of an exportable surplus of 150 million centals.

If this new supply of 150 million centals is added to the 344 million centals which were available at 1st August 1924, an aggregate exportable surplus of 494 million centals is reached, available during the period between 1st August 1924 and 31st July 1925.

By way of comparison, the subjoined figures show the quantities which, in theory, were available between 1st August and the subsequent 31st July, and the quantities actually exported during those periods, for the three years preceding the current season.

	Quantities exportable	Quantities exported
	(*Million centals*)	
1924-25	494	—
1923-24	570	487
1922-23	500	429
1921-22	471	415

The quantity available for export during the current season appears to be less than that during 1923-24 by fully 75 million centals, and is only slightly larger than the actual exports of that year. On the other hand, the quantity is about equal to the exportable surplus of 1922-23, and is larger by 65 million centals than that actually exported in the last mentioned season.

Requirements of Importing Countries.

Any estimate of the probable requirements of the importing countries has even more elements of uncertainty than are involved in ascertaining the surplus available in exporting countries.

A comparison of yields and importations during the twelve months subsequent to the harvests shows that in the seasons 1921-22, 1922-23 and 1923-24 (omitting data of stocks at the opening and close of each season) the *apparent* consumption of the chief importing countries was subject to considerable fluctuation varying from 881 million centals in 1921-22 to 793 million in 1922-23 and to 927 million in 1923-24. Although the yield in these countries in 1922 fell short by about 100 million centals of that in 1921, their importations during the season 1922-23 hardly exceeded those of the corresponding period in 1921-22. Per contra, with a yield in 1923 of about 90 million centals greater than in 1922, imports during the season 1923-24 reached a quantity of about 50 million centals more than that of the same space of time in 1922-23.

Such fluctuations may be partly explained by the fact that the actual consumption has a tendency to increase in plentiful seasons, and to decline when harvests are scanty, but augmentations and reductions in stocks are also contributory factors. Doubtless these stocks were larger at the outset of the 1921 season than they were a year later, and less important at the beginning of the season 1923 than they had become at the like period in 1924.

Hence, the *apparent consumption* during a season, obtained by adding together the yield of each respective year and the imports during the twelve months subsequent to harvest, must be considered to be *below the actual consumption* in a season of deficient crops, when stocks tend to diminish, and *above the actual consumption* in a plentiful season, when stocks are on the increase. With special regard to the imports during the season 1923-24, it must be especially noted that the Far East absorbed unusual quantities, and Japan, after the earthquake, was a very large importer.

Taking these points into account, it may safely be assumed that, while the yields in the chief importing countries in 1924 were lower by about 60 million centals than those in 1923, the import requirements during the season 1924-25 would not be likely to outweigh by any corresponding quantity the importations from 1st August 1923 to 31st July 1924.

Adopting as a basis of comparison the position evolved during the season 1922-23, when the yield was below that of 1923, and yet the importations fell short by about 50 million centals of those which took place during the season 1923-24, it may be expected that the requirements during the twelve months after the harvest of 1924 will be less than the quantity imported in the past season, However, considering the poor quality of the new wheat in several countries of Europe and the generally deficient crop of rye (an important alternative food grain in some regions), it seems more prudent to admit theoretically that the aggregate requirements of importing countries between 1st August 1924 and 31st July 1925 might prove equivalent to their imports in the like period of last year, totalling about 485 million centals.

Summary of the Position.

On the one hand the quantities available for export during the season 1924-25, estimated at about 494 million centals, and on the other hand the probable requirements of importing countries during the same period, are placed in juxtaposition. These requirements cannot be precisely defined, but with the experience of the past seasons and consideration of the points already mentioned, they may fairly be stated at 485 million centals. The outcome is that the available supply is in close correspondence with the requirements, and allows only a narrow margin, a result differing greatly from those in recent seasons. In fact, although the situation of the wheat supply need not give rise to anxiety, it must be admitted that it is far from being so favourable as in late years, when the available supply largely exceeded the probable requirements.

It might be as well to add that, with the rise in prices, consumption may fall short of the forecasted figures ; and in that case some stocks of old wheat will remain on hand at the close of the current season. It must, however, be remembered that estimates of yield are still only preliminary and may have to be reduced later, while it has to be emphasized that the new crops of the southern hemisphere may afford results less favourable than those forecasted at present. If this should happen, there might be danger of absence of equilibrium between the supplies of wheat and the normal requirements.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

We deeply regret to record the death of Mr. F. T. T. Newland, late Government Agricultural Engineer, Madras, who left the Department on proportionate pension only a few months ago.

Mr. R. B. Ewbank, C.I.E., I.C.S., Deputy Secretary to the Government of India, Department of Education, Health and Lands, has been granted combined leave for 10 months and 16 days from 11th March, 1924. He was placed on deputation as Secretary to the Colonies Committee from 12th March to 23rd July and 4th to 6th August, 1924, and consumed leave during that period.

Dr. W. H. Harrison, Joint Director, Agricultural Research Institute, Pusa, and Imperial Agricultural Chemist, has been granted combined leave for eight months from 1st March, 1925.

Mr. A. Howard, C.I.E., Imperial Economic Botanist, Pusa, has been appointed Director of the Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India.

Mrs. G. L. C. Howard, M.A., Second Imperial Economic Botanist, Pusa, has been appointed Physiological Botanist, Institute of Plant Industry, Indore.

Mr. E. Shearer, M.A., B.Sc., formerly Imperial Agriculturist, Pusa, has been appointed Principal, East of Scotland College of Agriculture, Edinburgh.

Mr. E. Ballard, B.A., formerly Government Entomologist, Madras, has been appointed Cotton Entomologist, Queensland.

Mr. G. R. Hilson, B.Sc., Cotton Specialist, Madras, has been appointed to officiate as Director of Agriculture, Madras, *vice* Mr. R. D. Anstead granted leave.

Mr. D. Balakrishna Murti Garu, Professor of Agriculture and Superintendent, Central Farm, Coimbatore, Mr. S. Sundararaman, M.A., Government Mycologist, Madras, and Mr. G. N. Rangaswami Ayyangar, B.A., Millets Specialist, Madras, have been confirmed in the Indian Agricultural Service from 29th October, 1924.

Dr. W. Burns, Economic Botanist to Government, Bombay, has been granted leave on average pay for six months from 1st May, 1925, Mr. G. B. Patwardhan officiating.

Captain G. G. Howard, M.R.C.V.S., Deputy Director of the Civil Veterinary Department, Orissa Range, has been confirmed in the Indian Veterinary Service.

Rai Sahib Priya Nath Das acted as Deputy Director, Civil Veterinry Department, North Bihar Range, from 13th September to 15th October 1924, *vice* Captain P. B. Riley on deputation for training at Muktesar.

The services of Captain J. B. Idle, Superintendent, Civil Veterinary Department, have been placed at the disposal of the Special Officer, Civil Veterinary Department, Burma.

Major R. F. Stirling, F.R.C.V.S., Offg. Veterinary Adviser to the Government of Central Provinces, has been granted combined leave for nine months from 7th November, 1924.

On relief by Mr. J. H. Ritchie, Mr. R. H. Hill, Offg. Deputy Director of Agriculture, Northern Circle, Central Provinces, has been transferred in the same capacity to the Southern Circle, Nagpur.

On relief by Mr. R. H. Hill, Mr. J. C. McDougall, M.A., B.Sc., Deputy Director of Agriculture, Southern Circle, Central Provinces, has been placed on special duty in the office of the Director of Agriculture, Central Provinces.

NEW BOOKS

On Agriculture and Allied Subjects

1. Essentials of the New Agriculture, by H. J. Waters. Pp. viii +549. (Boston and London : Ginn & Co.) Price, 7*s.* 6*d.*
2. Elements of Rural Economics, by T. N. Carver. Pp. v+266. (Boston and London : Ginn & Co.) Price, 7*s.*
3. Soils and Crops, by J. H. Gehrs. Pp. viii+444. (London : Macmillan & Co.) Price, 6*s.* 6*d.*
4. Recent Developments in Cattle Breeding, by G. F. Finlay. Pp. 62. (Edinburgh and London : Oliver and Boyd.) Price, 2*s.* 6*d.*
5. Grapes, Peaches, Melons, and How to Grow them. A Handbook dealing with their History, Culture, Management and Propagation, by T. W. Sanders and J. Lansdell. Pp. 150. (London : Collingridge & Co.) Price, 5*s.*
6. Colour Planning of the Garden, by G. F. Tinley, T. Humphreys and W. Irving. Pp. 324. With 300 drawings in colour by Miss M. Walters Anson. (London : T. C. and E. C. Jack, Ltd.) Price, 42*s.*
7. A Text Book of General Botany, by G. M. Smith, J. B. Overton, E. M. Gilbert and others. Pp. 409. (London : Macmillan & Co.) Price, 16*s.*
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ERRATUM

Vol. XIX, Pt. VI, p. 616, line 15, *substitute* " fertile " *for* " sterile."

HIS EXCELLENCY LORD READING, VICEROY AND GOVERNOR-GENERAL IN INDIA.

ORIGINAL ARTICLES

THE TECHNOLOGICAL RESEARCH LABORATORY OF THE INDIAN CENTRAL COTTON COMMITTEE.

Readers of the " Agricultural Journal of India " are already aware that as soon as they were assured of funds the Indian Central Cotton Committee lost no time in putting into force the recommendation of the Indian Cotton Committee of 1917-18 and of the Board of Agriculture in India of 1919 that provision should be made for technological research on cotton and particularly for the testing of new cottons for Agricultural Departments. Work was started in January 1924 with the arrival of Mr. Turner (recently Professor of Textiles, Manchester College of Technology) who was appointed Director of the Laboratory.

The Laboratory consists of two sections, *viz.*, the Research Laboratory and the Spinning Laboratory. The former is temporarily housed in the Victoria Jubilee Technical Institute ; the Spinning Laboratory has already been completed and work started in July last. Work on the main building of the Research Laboratory will be completed before the next monsoon.

A most interesting function took place in Bombay on 3rd December, 1924, when His Excellency the Viceroy formally opened the Spinning Laboratory, started the machinery and laid the foundation-stone of the Research Laboratory. We publish below His Excellency Lord Reading's speech and also the speech of the Agricultural Adviser to the Government of India who is *ex-officio* President of the Committee.

His Excellency, who was accompanied by Her Excellency Lady Reading, His Excellency the Governor of Bombay and Lady Wilson, and the personal staff, was received on arrival by the President, Vice-President and Secretary of the Committee and the Director of the Laboratory. After Their Excellencies were seated the members of the Committee were presented to His Excellency the Viceroy. A large and distinguished gathering of visitors was present at the ceremony including His Excellency the Naval Commander-in-Chief, the members of the Bombay Executive Council, the Minister for Agriculture, Bombay, a number of Ruling Chiefs, representatives of the Chambers of Commerce and Millowners' Associations, several of the Governors of the Indore Research Institute and several representatives of Provincial Cotton Committees.

Dr. Clouston's Speech.

Dr. D. Clouston, C.I.E., Agricultural Adviser to the Government of India and President of the Indian Central Cotton Committee, in requesting His Excellency the Viceroy to perform the ceremony, said :—

" YOUR EXCELLENCY—It is my very pleasant duty and privilege on behalf of the Indian Central Cotton Committee to extend a most cordial welcome to you and to Her Excellency Lady Reading and to express our extreme gratification at the honour which Your Excellency has conferred upon us by your presence here to-day. Your Excellency will perhaps permit me further to express our great pleasure that so distinguished a gathering representing so many interests, concerned directly or indirectly with the cotton industry, has met here with us to honour this occasion—an occasion which, we venture to hope, marks the inauguration of a new era in the annals of India's cotton industry.

" The Indian Central Cotton Committee cannot lay claim to a great age. We are still at the stage when the enquiry is frequently heard, who are the Indian Central Cotton Committee and what do they do. On the other hand, the industry which supports us and which has already begun to benefit by our activities has its origin in hoary antiquity. It will, therefore, be of interest if I trace the chain of circumstances which led to our establishment. From very early days cotton has been grown in almost all parts of India. For centuries the cultivator was content to grow the kind of cotton and to follow the methods of cultivation and marketing which were stamped with the seal of long established custom. As time progressed, the development of the textile industry in India and other countries resulted in a greatly increased demand for the fibre. Improved facilities for ginning, transporting and marketing the crop were introduced and a healthy export trade arose. Under the new conditions of trade various abuses crept in, and it became increasingly difficult for the cotton grower to maintain the quality of his produce. His seed got mixed in the factory with that of inferior sorts, and insect pests and fungoid diseases took a heavier toll of his crop.

" Since their inception the Imperial and Provincial Departments of Agriculture have, by giving special attention to the improvement of cotton, done their best to enable him to adjust himself to these new conditions. Improved strains of cotton have been evolved and better methods of cultivation introduced. But the activities of these departments have been restricted both by the need for economy and by the shortage of officers. Their small staffs have, moreover, been occupied in solving a diversity of problems spread over the whole field of agriculture. Much has been accomplished nevertheless within the last twenty years, and the results obtained have, we venture to say, opened up a vista of great possibilities for the development of India's cotton industry.

" Progress has been unduly retarded by the fact that the mixing of good cotton with cotton of an inferior quality is so commonly practised. This is done either

by mixing the two grades as *kapas* before ginning, or as lint before pressing. The result in both cases is the same ; the buyer becomes suspicious of all cotton offered as being of the higher grade and reduces his rates in consequence. In the former case, however, a double injury is done to the cultivator, for it results both in his having to sell at a reduced rate and in his getting mixed and inferior seed for sowing. Incidentally the pernicious practice of mixing also handicaps Agricultural Departments in their efforts to establish superior and uniform types of cotton over large areas.

" A further difficulty with which the departments have to contend is lack of information as to the real spinning qualities of their new cottons ; for the spinners, though always willing to help, are not in a position to give the detailed information required. It thus became apparent that all was not well with the cotton industry in India, and that, unless something were done to remedy matters, the position would gradually become worse. Government realized the seriousness of the situation and in 1917 the Indian Cotton Committee was formed.

" The age in which we live, Your Excellency, is an age of research and research is concentrated experience. It is not surprising, therefore, that among the recommendations made by the Indian Cotton Committee, research on cotton figured very prominently. They recommended (1) that the staff of the Department of Agriculture of each of the cotton-growing provinces should be increased with as little delay as possible, (2) that steps should be taken to stop such abuses as mixing and damping which have done so much to spoil the good name and lower the value of Indian cotton, and (3) that Departments of Agriculture should be brought into closer touch with the trade, and be provided with the means of getting more complete information regarding the qualities of the improved cottons they evolved. It was chiefly with the object of achieving the latter two aims that they recommended that a permanent Committee, to be known as the Indian Central Cotton Committee, should be constituted. This recommendation Your Excellency's Government was pleased to accept and the Indian Central Cotton Committee came into being in March 1921, and was duly incorporated as a permanent body with a definite constitution in May 1923.

" On the Committee we have representatives from all parts of India and from all sections of the cotton industry—from the consumer to the producer. We can truly claim to be an all-India body ; our funds come to us from all parts of India, and the work we have in hand is designed to benefit the industry throughout the length and breadth of this great Empire. It is, therefore, a very happy omen that on this occasion when we are about to embark on one of the main lines of our activity, Your Excellency, upon whose shoulders the cares of all India fall, has graciously consented to mark the event by your presence here to-day.

" And now, Your Excellency, permit me to refer to the work which we, as a Committee, have been able to accomplish during the short term of our existence, and to indicate very briefly what we hope to undertake in the future. We have been able

to advise Your Excellency's Government in regard to three important pieces of legislation, *viz.*, the Cotton Cess Act, the Cotton Transport Act and the Bill for the Regulation of Gins and Presses. Of these, all but the last have received the assent of Your Excellency's Government and been passed into law.

" The Cotton Cess Act makes provision for our legal constitution, and has provided the Committee with a means of obtaining funds for the furtherance of research.

" The Cotton Transport Act has been designed to eliminate, or reduce, the evil of adulteration in those tracts where the practice has arisen of importing cotton waste, or cotton of inferior quality, for mixing with superior grades with a view to reaping an illicit profit. This Act provides for the protection of prescribed areas by making illegal the importation of outside cotton into such areas except under license. The provisions of this Act have as yet been applied only in the Bombay Presidency, where in all 6 areas have been prescribed. Although this Act has been enforced for one season only, we are happy to be able to inform your Excellency that the results have justified our expectations.

" The Bill for the Regulation of Gins and Presses provides for the maintenance in every ginning and pressing factory of records of the cotton ginned and pressed ; for the submission of a return showing the number of bales pressed ; and for the marking and numbering of bales. This Bill is complementary to the Cotton Transport Act and will provide a check on the mixing of different cottons which are grown side by side in the same tract.

" We have also been able to advise the Government of Bombay in the preparation of the Bombay (District) Markets Bill. The object of this Bill is to provide for the establishment of properly regulated cotton markets, with a view to enabling the cultivator to secure an adequate price for his cotton.

" I have already referred to the fact that the passing of the Cotton Cess Act placed the Committee in possession of funds for the encouragement of research work, directed to the improvement of cotton growing and marketing. With the sanction of Your Excellency's Government the Committee have now adopted a definite research programme, and are working in co-operation with Provincial Departments of Agriculture and other institutions, to which they have made grants-in-aid for the investigation of various scientific problems relating to cotton. The lines of research include the improvement of cotton by breeding and selection, the investigation of fungoid diseases and insect pests, and the study of certain bio-chemical problems connected with the cultivation of cotton. In co-operation with the Durbars of 8 of the Central Indian States, the Committee are also financing a Central Institute for research on cotton at Indore, and have been fortunate in obtaining the services of two very eminent botanists who will control the work there.

" On the technological side, we have arranged to supply the Departments of Agriculture with detailed information as to the spinning qualities of the new types of cotton which they produce. With this end in view we have devised a scheme for

technological research. When this scheme is complete, we shall have two laboratories —a Spinning Laboratory and a Research Laboratory. The first of these has already been completed and equipped with a complete spinning plant and with an exhaustive range of instruments for testing cotton yarn. As these tests can be carried out on small samples, and at an early stage in plant breeding work, we hope to be able to guard agricultural officers against proceeding with a cotton which is of no intrinsic value from the spinner's point of view.

" The Research Laboratory which is in course of erection will be equipped with the necessary staff and fittings to enable a thorough chemical, microscopical and physical examination to be made of each cotton sent for trial. By collating the results obtained in these two laboratories, we hope to arrive at the position when by an examination of certain of the measurable properties of a sample of raw cotton, we shall be able to state fairly accurately how it is likely to behave when spun. We also hope to be able to place agricultural officers themselves in the position to measure some or all of these characters. We consider this line of research as one of the most important of our activities, and we are gratified that Your Excellency has been graciously pleased to mark its importance, by consenting to open one laboratory and to lay the foundation-stone of the other.

" At an early stage it became obvious that one of the great difficulties connected with cotton improvement in India was the shortage of qualified workers with a knowledge of scientific methods as applied to cotton investigations. The Committee therefore decided to give six research studentships annually to distinguished graduates of Indian Universities to enable them to undertake research work on cotton problems under the direction of experienced investigators. In this way it is hoped to build up a corps of qualified workers, and we believe the improvement of this historic industry will provide a worthy career for the young educated Indian who desires to serve his country.

" It will thus be seen that this Committee, which is representative of the various interests concerned with cotton, is carefully considering the place for research in different branches of the cotton industry, and that it has already done a considerable amount of solid work in starting and co-ordinating schemes with that end in view. The main aim of that research is to help the cultivator to help himself by enabling him to produce a larger quantity of cotton of a quality for which the buyer will readily pay a higher price.

" It is the determined pursuit of a common aim, Your Excellency, that has enabled the Committee to produce the results which have already been achieved. We come from many parts of India and represent interests which in the past have been held to be divergent ; but in our efforts to promote the welfare of a great industry, and in particular that of the cotton grower, we have worked harmoniously, and Indians and Europeans, non-officials and officials, growers, traders and spinners have come to know one another and to appreciate each others' standpoint.

"It is difficult to discriminate where all have worked so whole-heartedly to a common end, but it is only right that I should bring to Your Excellency's notice the cheerful way in which our up-country members have faced the sacrifice of time which periodical meetings in Bombay entail. Further, I should like to express my appreciation of the invaluable support which we have received from the cotton trade, and of the generous way in which many business men of high standing have made the work of the Committee their constant care. To their hearty co-operation much of the success we have attained is rightly due.

"The passing of the Act, which incorporated the Committee as a permanent body, we feel to be an expression of the confidence of the Government of India in our usefulness. Your Excellency's presence amongst us to-day gives us a further demonstration of your interest in our work, and inspires us to further effort.

"It is now my privilege, on behalf of the Indian Central Cotton Committee, to ask Your Excellency to open the Spinning Laboratory and lay the foundation-stone of the Research Laboratory."

H. E. The Viceroy's Speech.

His Excellency the Viceroy said :—

"It gives me the greatest pleasure to take part in this inaugural ceremony to-day for several reasons. In the first place I am enabled to express my high appreciation of the value of technological and other forms of research connected with cotton with which this ceremony is primarily concerned ; and in addition there is the wider subject of the activities of the Central Indian Cotton Committee and the general question of the cotton industry in India as a whole in which I take the warmest interest and to some aspects of which I desire to draw attention.

"The Indian Central Cotton Committee lost no time after their formation in carrying out the recommendations of the special Indian Cotton Committee of 1919 regarding the appointment of a technologist and the erection and equipment of a laboratory and experimental spinning installation in which accurate tests can be made and correct judgment concerning the value of varieties of cotton sent for test can be reached. The spinning test represents the main avenue to all technological research in cotton ; and the experimental spinning plant, erected here, now enables the most satisfactory method of ascertaining the value of cotton by actual spinning test to be carried out under expert control. These tests will be supplemented by other scientific processes directed towards classifying the properties of various types of Indian cottons ; and these results will be correlated with the results from spinning tests. Properties of fibre and yarn are also to be investigated. For some of these processes a laboratory will be required where physical, chemical and microscopical examinations can be conducted. A building has been designed and begun

for these purposes ; but meanwhile, thanks to the kindness of the Trustees of Victoria Jubilee Technical Institution, the actual laboratory tests have not had to wait upon the completion of the building and are already being carried out in the premises of the Institution. I need not emphasize the great value of this work. Its effect in assisting in the selection of the most suitable varieties of cotton for growing and in placing facts before the producers and consumers of first importance in the marketing of cottons cannot be over-estimated. I heartily congratulate all those concerned in the successful start made in technological research work here, and I also felicitate the public interested in cotton on the possession of an institution designed for scientific tests which, I am confident, will be of the greatest value in the history of this most important industry.

" It may appear in Bombay unnecessary to dwell upon the wider aspects of the work of which the experimental spinning plant is only part, though a very important part ; for Bombay is the great cotton centre. Not only does the Presidency grow large areas of cotton but much of the prosperity of Bombay City itself is bound up with the cotton industry and large numbers of persons are directly concerned with the purchase, marketing and export of cotton or with the spinning and manufacture of cotton cloth and yarn. The question of cotton supply has accordingly a direct reaction on the general conditions of the financial, commercial and industrial prosperity of this city ; but this lively interest is now universal outside Bombay ; and perhaps in some quarters in India men's minds are apt to dwell in some perplexity on problems of financial stringency and of needs for social, administrative and economic improvements of various kinds without realizing, as keenly as I do and as many, I feel sure, in Bombay also do, that the cure for many of these difficulties and defects lies in increase and improvement of production. The effect of increased production in adding directly and indirectly to State revenues and in enhancing the prosperity of the producer, the manufacturer and the industrial labourers will, I am confident, show the way of escape from many of those difficulties and problems for which at present no easy solution can be found.

" One of the more obvious means of improving production in India lies in concentration on the improvement of the cotton crop. India is vitally interested in cotton. Many parts of the world can produce food-stuffs ; but the favoured areas which have conditions suitable for the production of cotton lints for use for clothing and numerous other purposes are limited. India, however, has the priceless heritage of a climate and soil favourable for cotton production, and it would be madness to neglect or squander that fair inheritance or to fail to use every effort to improve it by wise stewardship. India consumes a large quantity of cotton goods. It has an extensive cotton export trade. It is keenly interested in the manufacture of cotton goods both through well-established and efficient spinning mills, in which much capital has been invested and which give employment to large numbers of workers, and through widespread " cottage industries " which produce large quantities of hand-woven yarn and cloth.

" It must be remembered that India is not only the largest cotton-producing country in the British Empire, but is also the second largest cotton-producing country in the world. Moreover, America, the largest producer, is itself now yearly absorbing to an increasing extent its own produce. For this reason, not only in the interests of India itself, but in the interests of the Empire-supply and world-supply, the cotton industry of India holds a most important position and India offers the greatest possibilities for a considerable increase in the supply of cotton in the near future.

" The possibilities of increase in India lie in various directions. There is the question of the expansion of the area under cotton which is largely connected with the extension and improvement of irrigation and the exploitation of new areas suitable for cotton cultivation. Another aspect of the case is the possibility of securing a better average yield per acre in existing cotton areas by selection and stabilization of the better varieties of cotton or by the introduction of new kinds. There is also the question of the prevention and cure of diseases and pests to which the crop is peculiarly liable and which cause a considerable volume of loss each year. There is also need to study the export and mill demand more closely and to aim at improvements in the production and marketing of the desired varieties in commercial demand for the cotton trade with the mills in India or other countries. This includes the prevention of adulteration, deterioration and admixture and the stabilization of the supply of various types in demand in various markets. As an illustration of the great scope for improvement I may note that the Cotton Committee in 1919 stated in their report that the average yield of Indian cotton was only 85 lb. of lint to the acre as compared with 200 lb. in America ; and that there was in addition defective marketing resulting in losses for Indian cotton of 10 per cent. more in the blow room as compared with American and Egyptian cottons. The Committee also found that before the War Lancashire, the best available cotton market, took little Indian cotton owing to the short supplies from India of staple cotton approximating the commercial inch standard.

" The time at my disposal does not permit me to do more than indicate in the broadest manner the great importance of the field open to the labours of the Central Indian Cotton Committee, the immense potential value of the work on which they are engaged and the numerous problems, of which I have only enumerated a few salient points, remaining to be solved by their efforts and advice ; but if in my brief sketch I have been able to communicate even in some degree the keen interest which I feel in their work and my deep appreciation of the importance of their labours in the interests of the progress of India and the prosperity and welfare of the people of India, I shall have been amply rewarded.

" The Central Indian Cotton Committee has been set up as a result of the report of the Special Cotton Committee of 1919. Broadly speaking, apart from formal activities, the Committee is a central body charged with the promotion of all measures which will tend to further the improvement of the cotton-growing industry in India,

The *personnel* consists of a fully representative body including the Agricultural Adviser to the Government of India as President, and as members, the Directors of Agriculture and other experts of the Agricultural Department in the cotton-growing provinces, the Director General of Commercial Intelligence, the representatives of the Chambers of Commerce and Commercial Associations, commercial representatives specially nominated by the Local Governments, representatives of the Co-operative Credit Societies, of the cotton growers and of the Indian States. The representative character of the Committee specially qualifies it to advise the Central and Provincial Governments in all matters concerning the industry and affords a common ground on which all sections of the cotton trade, the producers, the traders, the manufacturers and the agricultural and other experts of the Central and Local Governments can meet and discuss difficulties and take joint action to promote objects which are alike the concern of the Government of India, the Local Governments and the Indian States.

"With the passing of the Cotton Cess Act, the Cotton Transport Act, and the active consideration of a Bill for the Regulation of Gins and Presses, the machinery for extending the operations of the Committee is in the process of being perfected. The Committee has already excellent achievements to its credit and great results are to be expected from the schemes of the Committee for the promotion of agricultural and technological research. The Committee can rely on my warm sympathy and on the support of the Member of my Council, Sir Narasimha Sarma, in their operations ; and I know that the Ministers-in-Charge of Agriculture in the cotton-growing provinces keep in very close touch with their work. I commend the work of the Committee to the public generally because I am convinced that it is of primary importance to the welfare of India and to the prosperity of her people.

"I will now proceed to perform the inaugural ceremonies."

As His Excellency the Viceroy explained in acknowledging the vote of thanks moved by the Vice-President, the occasion was unique not only because of the great importance to India of the cotton industry, but because of the great interest which every one has in the improvement of the supply of this most important source of clothing.

A booklet describing the Laboratory and its equipment has been published and will be forwarded on application to any readers of the "Agricultural Journal of India" who have not already received a copy. A quotation from this may be permitted as it explains the proposed scheme of work—

"Unlike many other raw materials there are no simple analytical or mechanical tests to which cotton can be subjected to ascertain its value. In consequence cottons are marketed largely on their name and reputation and judged by empirical standards. Hence the only way of really ascertaining the value of a new cotton, at present, is to carry it through all the processes of spinning. The agricultural officer engaged on cotton-breeding operations needs all the assistance which it is possible to give him in determining at the earliest possible stage which of his new types are likely

to prove both acceptable to the spinner and profitable to the grower. The repeated and unanimous statements of agricultural officers that they needed help in this direction led the Committee to decide to provide arrangements for work of this nature under their own direction. The Technological Laboratory which has just been completed will undertake properly controlled spinning tests for Agricultural Departments, will be able to interpret the results and arrange later for the necessary full scale commercial mill trials before new cottons are brought into general cultivation. Since the laboratory equipment is designed to deal with quite small quantities where necessary, it is obvious that such tests should save agricultural officers much time in their work and should render it impossible for an unsuitable type of cotton to be brought into cultivation.

" Essential as the spinning test is in the present state of our knowledge of the cotton fibre, it is by no means ideal as the only test to be applied to new cottons, being not only somewhat expensive but relatively slow. It is highly desirable that an attempt should be made to determine whether it may not be possible ultimately to predict the spinning value of a cotton without having recourse to the spinning test itself, or at any rate to design simpler laboratory methods which will provide sufficient information to enable the plant-breeder to select the best type for further work. Fortunately the additions to our knowledge of the cotton fibre which have resulted from recent investigations in England and America indicate that this should be a particularly fruitful field of work. Once the botanist can be told which of the measurable physical and chemical characters of the cotton hair are of importance in determining spinning quality, he will have a far better chance of determining their inheritance and can guide his operations accordingly. An extensive series of investigations has therefore been planned into the various types of Indian cottons and in every case an attempt will be made to correlate the properties of the cottons with the results of the spinning tests. For these supplementary investigations of a scientific nature the Central Committee decided to erect a Research Laboratory adjacent to the Spinning Laboratory, the provision of which, along with the necessary staff and equipment, renders possible a complete survey of the present standard Indian cottons, as well as the investigation of new types. By repeating these tests on standard cottons from year to year, it will be possible to issue each season a report on the quality of the different cottons, which will no doubt be a useful complement to the information already published regarding the yield. From the various investigations which will be undertaken it is confidently expected that much benefit will be derived in connection with the selection of suitable varieties for growing, and further, that facts concerning different growths will become available which will be of the greatest assistance in the marketing of Indian cottons.

" The small Research Institute which these two laboratories will form will be unique. Two important research institutes have recently been established in England for scientific research in the cotton industry, but their objective is mainly the utilization of the raw materials. In America similar work has been conducted during the

last few years and has had important results not only in the improvement of processes but in the organization of marketing. But the Indian Central Cotton Committee believes its modest institute to be the only one in the world concentrating on the improvement of the raw material and on the growers' needs. It looks to it for far reaching results and for most important assistance in its efforts to help the cotton grower to help himself and to make cotton production more efficient and more profitable."

SIR FRANK GEORGE SLY, K.C.S.I., D.Litt.

AN APPRECIATION.

His Excellency Sir Frank Sly who retired in January this year entered the Indian Civil Service in 1887 and was posted to the Central Provinces. After seven years' district work he was promoted to the Government of India as Under Secretary in the Department of Revenue and Agriculture. At the early age of 31 he officiated as Secretary in the same department. At a later date he again served for some time under the Government of India as Inspector General of Agriculture. But the greater part of his service was spent in the Central Provinces where he held several important posts, including that of Commissioner of Settlements, Director of Agriculture, Commissioner, first of Berar and then of Nagpur, Chief Commissioner and finally that of Governor.

During the course of his service he served on several important Commissions and Committees. He was a member of the Royal Commission on the Public Services, Chairman of the Public Works Department Reorganization Committee and of the Champaran Enquiry Committee, and Deputy Chairman of the Franchise Committee.

I had the great pleasure of knowing him intimately and serving under him as Deputy Director of Agriculture in the Central Provinces. To know him and to work with him was to admire his fine qualities of head and heart. He was a great administrator, a good sportsman and a true friend. I still have happy memories of the many pleasant days spent with him on the *jhils* and on the tanks of the Central Provinces when the snipe and duck were in.

His career generally has been fully described in the public press, but to the very important part he played in organizing the work of Agricultural Departments in this country less prominence has been given. He officiated as Inspector General of Agriculture from December 1904 till February 1907. At this time the Imperial and Provincial Departments of Agriculture were in their infancy and the total staff of agricultural experts was very small. As Inspector General of Agriculture one of his main duties was to guide and co-ordinate the experimental and research work of Agricultural Departments throughout India; to publish and criticise the results obtained therefrom, and to suggest new lines of work which might profitably be taken up. In his official capacity he visited every province and gave the Directors of Agriculture thereof most valuable assistance in organizing their departments. His wide experience gained as Inspector General of Agriculture for all India, and as Director of Agriculture in the Central Provinces enabled him to bring to the

SIR FRANK GEORGE SLY, K.C.S.I., D.Litt.

notice of the department of one province the results obtained by research and experiment in others.

Being a strong believer in the possibility of developing agriculture in this country on scientific lines, he persistently brought to the notice of Local Governments the imperative necessity for the employment of scientific experts to guide and control agricultural research and education. It was largely on his advice that the Pusa Research Institute and provincial agricultural colleges were built and so well equipped with staff, laboratories and experimental farms of their own, on which the students could be taught the practical side of agriculture. Pusa was to be the Rothamsted of India—to which successful students of provincial agricultural colleges could go for a post-graduate training in methods of research.

To stimulate a wider interest in the development of agriculture, he recommended that agricultural societies should be formed in the districts, that demonstration plots should be opened in the villages and that leading agriculturists should be encouraged to start seed farms for the propagation of seed of the improved varieties evolved by the department. He recommended, too, that the work of Agricultural Departments should be given greater publicity and that the results of research and experimental work should be published as soon as data of importance were obtained from them. The publication of the Agricultural Journal and of bulletins, memoirs and leaflets was part of this general policy of bringing the work of Agricultural Departments to the notice of the people interested in the development of agriculture. All these lines of extension work proved thoroughly sound and do credit to Sir Frank Sly who devised them.

Another great advance made during his tenure of office was the creation of the Board of Agriculture in India. This Board has served a most useful purpose as an advisory body and has done much to correlate the activities of agricultural experts throughout this land.

To Sir Frank Sly is thus due much credit for the very prominent part he played in laying the foundation of scientific agriculture in India. He planted and tended with care the young seedling which has since developed into a fruitful tree. His boundless enthusiasm enabled him to overcome the manifold difficulties which confronted him, for he foresaw the beneficent results which would accrue from the application of science to India's greatest industry.

D. Clouston.

A PERSONAL TRIBUTE.

I first met Sir Frank Sly in the early part of 1905 when he was acting as Inspector General of Agriculture. At that time I had no connection with Government, but had been asked to attend the first meeting of the Board of Agriculture for India at Pusa, which had just been taken up as the main centre of experimental

work in agriculture. I went to Pusa in fear and trembling, thinking that the President of this august body would be a very dignified and unapproachable person. When we arrived, however, we were met by the Inspector General himself, and found him then, as I have always found him since, a very human person, ready to welcome and ready to help workers of every kind and to make them at home.

I soon found, however, that he was a man of large vision and of great ideas. I shall never forget that first meeting of the Indian Board of Agriculture. We had, most of us at any rate, been living in a rather small and provincial world. But the Chairman, Sir Frank Sly, quickly lifted us all on to a higher plane and showed us our work as a contribution for the whole of India. It was the day when Pusa was to be an Agricultural College for the whole of India, when crops were considered as being independent of political boundaries, and when India was, in agricultural matters, considered far more as a unified entity than it has since become—for better or worse. Most of the men present were new to agricultural investigation in India or to agricultural propaganda—for the technical staff were mostly new to the country. But serious agricultural investigation was itself new in India, for the existing experimental stations had mostly been conducted very much on routine lines, and agricultural propaganda had hardly been taken seriously. Sly towered so far above most of those present, both in his conceptions of what was possible and in his knowledge at least of how to bring existing information to the notice of cultivators and hence into practice, that he would at once have been a leader even if he had not been in the chair.

During the following year or two, while he still remained as Inspector General of Agriculture, I saw much of Sir Frank Sly. We travelled together in Assam and in Eastern Bengal. He sought my advice in planning the beginnings of agricultural experiments near Dacca, and I had the pleasure of showing him something of tea culture and manufacture, and of sisal hemp cultivation in the Indian tea districts. I have never had a more delightful travelling companion, and in this journey I learnt to admire more than ever his breadth of view and his ability to conceive of a subject as above superficial and temporary considerations.

Sir Frank Sly presided at the second and third meetings of the Board of Agriculture in 1906 and 1907. These were the days of rapid advance. While in 1905 we considered the planning of one Agricultural College for all India, in 1906 it had been decided to establish one in each of the large provinces, and under Sly's guidance a scheme was worked out for these. Men were arriving every few weeks to take up positions in the various Agricultural Departments, and to all these I think he appeared as a great personality.

Shortly after the meeting of the Board of Agriculture at Cawnpore in 1907, Sly ceased to be Inspector General, and again became Director of Agriculture in his own Provinces. I have kept in touch with him, though I have seen little of him since that time. Always, however, when we have met he has shown the same hu-

man character, the same far vision, and the same breadth of view which struck me so much in the olden days.

During the years when he was Inspector General of Agriculture it will be generally recognized that the foundations of the Indian Agricultural Departments, as we now know them, were laid. Whatever they are to-day,—whatever their value, whatever their use,—is built on the foundations and on the plan that he sketched when he was the adviser of the Government of India in matters relating to agriculture. I think it will be generally recognized that the result has been on the whole valuable. Others have built the edifice: he largely assisted in laying the foundation. So, as he leaves India, I cannot resist the invitation to write a note to indicate something of the impression given by Sir Frank Sly in the great days when he was Inspector General of Agriculture.

HAROLD H. MANN.

THE PROBABLE ERROR IN FIELD EXPERIMENTS IN AGRICULTURE.

BY

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In a recent number (Vol. XVIII, Pt. 5) of the "Agricultural Journal of India" Mr. B. N. Sarkar has discussed the question of estimation and value of "probable errors in variety trials." As the problem is essentially one of a statistical nature, a discussion from the statistical standpoint may prove useful.

From the statistical point of view the factors which affect the yield of paddy (or other crops) may be analysed into several distinct groups.

Consider any particular variety. Even if external conditions are kept absolutely uniform, slight variations in yield will still occur from plant to plant. Such deviations constitute the organic variability of the plant. They will however cancel out if we take the average of a large number of plants and the "mean yield" may be considered to be a stable constant for the variety. The "mean yield" of different varieties will however be different, and the difference in mean yield of two varieties may be conveniently called the "mean organic difference in yield."

Now consider the external factors. Innumerable small fluctuations will occur (from plot to plot or from experiment to experiment) in puddling or levelling the land, manuring, watering, drainage, exposure to rain and sun, etc. These external fluctuations also will however cancel out on averaging for a large number of experiments and may be grouped under "random fluctuations."

"Systematic variations" in the external factors, such as differences in the composition of the soil, in the nature of manure used, in methods of cultivation or in the fertility of land, will, in general, also occur and cannot always be removed. In addition, large accidental errors such as destruction of crops by crabs, rats, birds or other pests, or mistakes in manuring, harvesting or threshing may affect different experiments or different plots in different degrees. Mr. Sarkar says that such accidental errors can be considerably reduced by careful supervision. I shall assume that they are negligible.[1]

There will also remain the random errors of measurements and certain other purely statistical errors. If the number of experiments, *i.e.*, the size of the sample,

[1] These errors are of such a particular nature that a general discussion is theoretically impossible. My assumption, although never strictly true, is therefore unavoidable.

be very large, we can obtain precise information about the value of the " mean yield " and its probability. But in agricultural work the number of experiments is usually small, very often less than 10 or 12, and, as " Student " pointed out some time ago,[1] the probable error found from such small samples is subject to great uncertainty and " judgments reached in this way may become altogether misleading."

Grouping together the different random fluctuations and neglecting large accidental errors we thus have :—

(A) Organic differences in yield.
(B) Systematic variations of the external factors.
(C) Random fluctuations and statistical errors.

Field experiments in agriculture are of two different kinds :—

(1) " Variety trials " in which different varieties are used and, keeping external factors as uniform as possible, the organic differences in yield (A) are determined. The chief point here is to reduce (B) to zero. But this is often impossible in practice ; for example, variations in fertility of the land cannot possibly be removed. It then becomes necessary to estimate the effects of (B) and allow for them as accurately as possible.

(2) In another class of experiments, (A) is reduced to zero, *i.e.*, only one single variety is used and the effect of (B) is sought to be determined with accuracy. Experiments with different kinds of soil, or different kinds of manure or different methods of cultivation are typical illustrations.[2]

The problem of estimating (C) remains the same in either class of experiments. It is entirely a statistical question.

In the case of " variety trials" we have the additional problem of estimating (B). This is partly empirical and partly statistical.

I shall first consider (C).

Random Fluctuations and Statistical Errors.

The " mean difference in yield " of any two varieties may be calculated in two slightly different ways. We may first calculate the mean yield of each variety and then find the difference in the mean or we may first calculate the individual difference in yield of adjoining plots and directly find the mean of these differences. So far

[1] " The Probable Error of a Mean." *Biometrika*, VI (i), 1908, 1-25.

[2] The generally accepted experimental procedure is apparently as follows. Long narrow strips of experimental plots are prepared and sown with the different varieties in regular recurring series. In the example given by Mr. Sarkar there were 60 strips, each 80′ long and 4′ wide, sown with 6 different varieties. Each variety thus occurred 10 times altogether. Calling the different varieties a, b, c, d, e and f, we may refer to the yields from the different plots in terms of the varieties. Thus the yield from the 1st, 7th, 13th, 19th, 25th, 31st, 37th, 43rd, 49th and 55th plot may be called a (1), a (2), a (3),.... a (9), a (10), from the 2nd, 8th, 14th ..50th and 56th will be b (1), b (2), b (3), .. b (9), b (10) and so on for the other plots.

as the value of the "mean difference" is concerned, the result will obviously be the same, since

Mean of (a)—Mean of (b)=Mean of (a—b).

I quote the figures given by Mr. Sarkar :—

	Kalamdan (*a*)	Indrasal (*b*)	Difference (*a*—*b*)
	703	670	+33
	705	630	+75
	653	560	+93
	640	615	+25
	700	542	+158
	715	667	+48
	647	702	—55
	848	750	+98
	918	758	+160
	870	830	+40
MEAN .	739·9	672·4	+67·5

The "mean difference" of course is the same whether calculated from 739·9 —672·4 or directly from col. 3.

Apparently however there is some confusion of ideas about the probable error of the difference. The probable error of the difference calculated directly is $\pm 14{\cdot}1$, while the probable error calculated with the help of the formula

$$e\ (a—b)=\sqrt{e^2\ (a)+e^2\ (b)} \quad \ldots\ldots\ldots (1),$$

[where e^2 (a) and e^2 (b) are the squares of the probable errors of mean (a) and mean (b) respectively] is $\pm 28{\cdot}5$. Mr. Sarkar evidently prefers the value obtained by the direct difference method, apparently because it gives a *lower value* in this particular example. This however may not always be the case. The direct difference method can easily give *higher values* of the probable error under other conditions.

The real point is that the direct difference method gives the correct value, while the formula (1) is only valid when the two experiments are entirely independent. The complete expression for the probable error of a mean difference (a—b) is

$$e\ (a—b) = \sqrt{e^2\ (a) + e^2\ (b) — 2\ r\ (a,\ b).\ e\ (a).\ e\ (b)} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

where r (a, b) is the coefficient of correlation between a and b.

Now in variety trials systematic variation in, say, the fertility of the land is bound to introduce correlation between the different variates and hence, *unless* (*B*) *is zero, i.e., unless the external conditions are absolutely uniform and there is no correlation between the variates, the abbreviated formula for calculating probable errors of a difference from the probable error of the "means" will give totally misleading results.*

We conclude therefore that *under usual experimental conditions the probable error of a difference should wherever possible be calculated by the direct difference method.*

I now pass on to the question of the restricted size of samples. The subject has been fully discussed by " Student " in a paper already cited and I need merely quote " Student's " results. He has determined the distribution of a quantity Z, which is obtained by dividing the difference between the mean of small sample and the true mean by the standard deviation of the sample and has also constructed a table for estimating the probability of occurrence of Z.[1] Let us consider the example given above. The mean difference is 67·5 and the standard deviation of the 10 differences is 61·26. Dividing 67·5 by 61·26 we get Z=1·10.

From " Student's " Table for n=10, p=·99539 and 1—p=·00461.

The odds are therefore 99539 to 461, or 216 to 1, that Kalamdan gives a greater yield than Indrasal.

Mr. Sarkar finds the value of the probable error of 67·5 to be 14·1. The standard deviation of the mean difference is therefore 20·9 and the mean difference in terms of its standard deviation is 3·238 nearly. From Tables of the Probability Integral, I find that $\frac{1}{2}$ (1+a) is ·999397 and $\frac{1}{2}$ (1—a) is ·000603. The odds are therefore nearly 1700 to 1 in favour of Kalamdan and are much greater than the odds obtained by " Student's " formula.

Of course in the present example it is practically certain that Kalamdan gives a greater yield than Indrasal, and it matters little whether the odds are 1700 to 1 or merely 216 to 1. But the need for caution is obvious and, since " Student " has shown that the probability integral gives too large a value for p when the probability is large, it is extremely important that the correct formula should be used otherwise misleading results may easily be obtained. I conclude that *in estimating the probable error of " mean difference in yield " the table given by " Student " should be used wherever possible.*

I wish to point out that the calculations involved are practically the same, as the standard deviation of the differences must be found in either method. "Student's" Table is also easily available. There is no reason therefore why "Student's" method should not be used more extensively.

The " direct difference " method cannot however be always used. In such cases it then becomes necessary either (i) to determine the correlation between the two variates and use formula (2) or (ii) get rid of the correlation by eliminating the variations in the external factors and then use formula (1).

In either case a further statistical correction will be necessary if the size of the sample is small. As I have already pointed out, this question was first investigated by " Student " in the paper cited above. Two further papers, one by Karl Pearson[2] and another by A. W. Young,[3] have completed " Student's " work in this subject.

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[1] This table has been reproduced as Table XXV, p. 36 of *Tables for Statisticians and Biometricians* (Cambridge University Press).

[2] " On the Distribution of the Standard Deviations of Small Samples." *Biometrika*, Vol. X, p. 522, 1915.

[3] " Standard Deviations of Samples of Two and Three." *Biometrika*, Vol. XI, p. 277, 1916.

Pearson says : "We think it must be concluded that for samples of 50 the usual theory of the probable error of the standard deviation holds satisfactorily, and that to apply it for the case of n=25 would not lead to any error which would be of importance in the majority of statistical problems. On the other hand, if a small sample, n=20 say, of a population be taken, the value of the standard deviation found from it will be usually *less* than the standard deviation of the true population" (p. 528). Tables were constructed by Pearson and Young for making necessary corrections. The correcting factors are given in the following table for easy reference. They are taken from Pearson's and Young's Tables ; but I have put them in a slightly more convenient form for actual use.

TABLE A.

Correcting factors for standard deviations of small samples.

Size of sample	Correcting factor	Size of sample	Correcting factor	Size of sample	Correcting factor
2	Indeterminate	11	1·1056	20	1·0541
3	1·7319	12	1·0955	25	1·0425
4	1·4142	13	1·0871	30	1·0351
5	1·2910	14	1·0801	35	1·0297
6	1·2247	15	1·0742	40	1·0260
7	1·1832	16	1·0691	45	1·0230
8	1·1547	17	1·0646	50	1·0206
9	1·1339	18	1·0607	75	1·0136
10	1·1181	19	1·0572	100	1·0120

To obtain the "corrected" standard deviation we multiply the observed standard deviation of the sample by the appropriate correcting factor taken from the above table. The probable error of the mean will then be obtained from the corrected standard deviation by ordinary methods. The use of the above table will be sufficiently illustrated in later sections.

Construction of the "Normal Fertility Curve."

I shall now consider the problem of estimating systematic variations in the external factors. In certain experiments such systematic variations of external factors are known to exist and cannot be removed. For example, in the illustration given by Mr. Sarkar there is apparently a variation of 40 per cent. in the fertility of the land from one end of the field to the other. It is obviously neces-

sary to make allowances for such variation. Mr. Sarkar has sought to eliminate the effects of such variations by two slightly different methods. In the first he uses one variety as a standard and with its help constructs a "normal fertility curve" for the whole field, while in the second he uses all the different varieties for the same purpose. He then uses the "normal fertility curve" as a standard and considers the difference in yield, *i.e.*, "the departures" from this normal.

The problem will be recognized by statisticians as one of "smoothing." What we want is the "smoothed normal" yield curve of the field as a whole. Each single plot gives a reading, a reading which is made up of the "normal yield" together with a certain deviation imposed upon it by the factors producing variation.

In general there is no reason why any particular variety should give more reliable readings than others. It therefore seems pretty clear that, *unless there is any special reason to the contrary, all the different varieties should be used to determine the "normal fertility curve" of the field.*[1]

The problem of smoothing has received a good deal of attention during the last few years[2] and a large number of formulæ are available for this purpose. It is not however an easy task to choose the most suitable method for any particular case. Mr. Sarkar has used the method of "moving averages"; it is certainly simple, but has no other special merit; it also suffers from the disadvantage that the normal yield for the end-plots cannot be determined by this method.

From the nature of the problem it seems clear that *a very smooth* rather than a very close fit is desirable. My own feeling is that Whittaker's probability method of smoothing would probably give very good results with the present type of material. It possesses several advantages; the total of the variates and their first and second moments (which are often required for statistical purposes) are the same in the smoothed table as in the actual statistics on which the smoothing is based; it has satisfactory logical basis in the mathematical theory of probability; it makes use of the whole material available to graduate each individual value; there is no difficulty near the beginning or end of the plot; and finally the computations are fairly easy and straightforward. The numerical processes are described in detail in Whittaker's book, but I am quoting the necessary formulæ in Appendix I for easy reference.

Taking 6 varieties and all 60 plots I get the following expression for the smoothed or graduated values

$$y = 9\ 17{\cdot}54 - 1{\cdot}34\ 65\ x - 0{\cdot}05\ 87\ 88\ x^2$$

[1] This would also serve to eliminate factors of differential fertility. Let us take an extreme case. Consider a field in which the fertility increases for one variety, say (a), and decreases for another variety, say (b), from one end to the other. The fertility curve for (a) and the fertility curve for (b) will then be two single straight lines inclined to one another. Using either the a-curve or the b-curve alone we may get fallacious results, but using both we can get rid of the differential factors.

[2] For an excellent account see "Smoothing" by E. C. Rhodes, *Tracts for Computers*, No. VI (Cambridge University Press, 1921) and also Chapter XI of Whittaker and Robinson's *Calculus of Observations* (Blackie & Co., Ld., 1924).

The graduated values[1] are given in Table I (col. 2) and are plotted as a graph in Diagram 1. Here y gives the yield in *tolas* and x represents the serial number of plots.

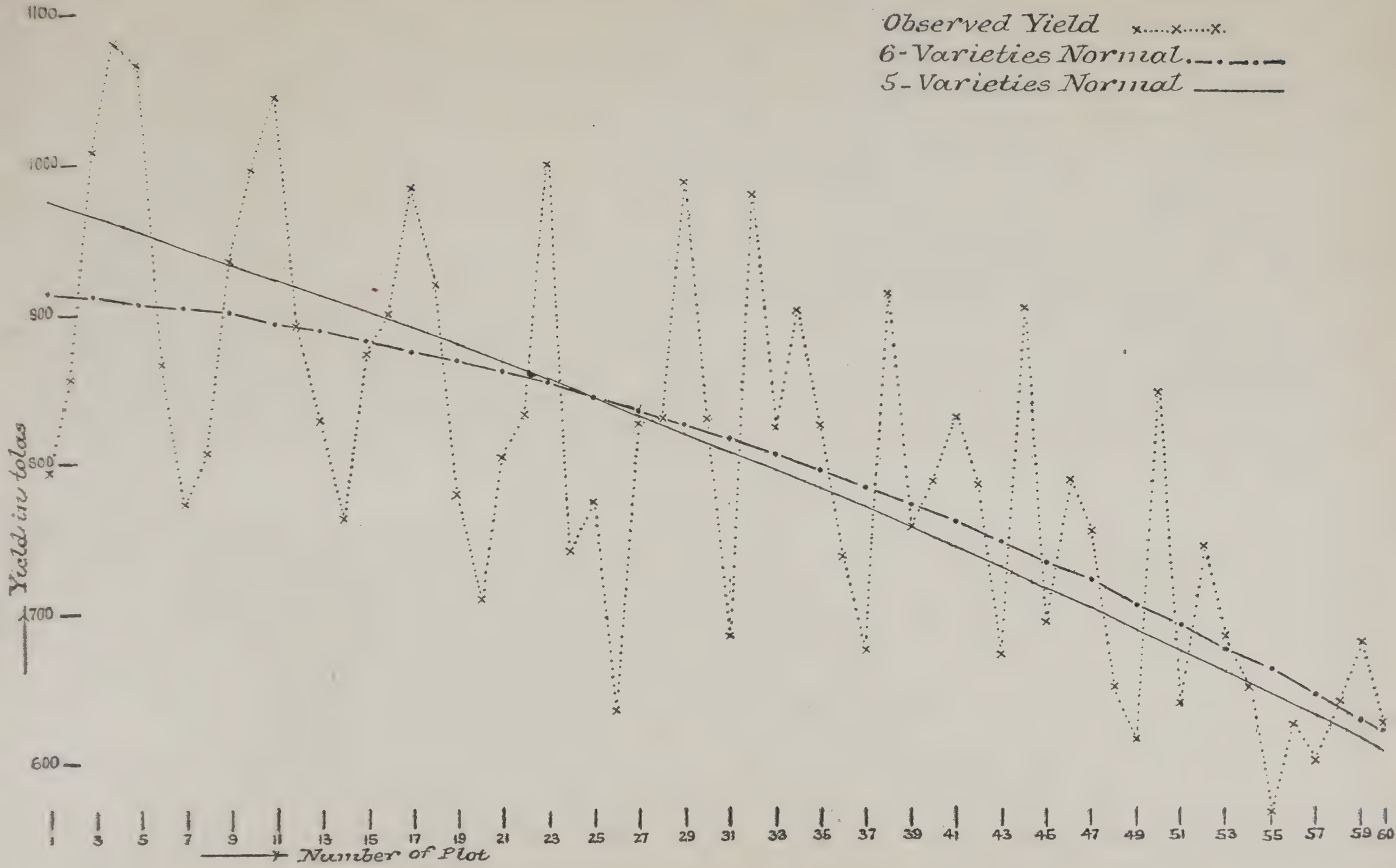
TABLE I.

"Normal yield" (by Whittaker's method).

No. of plot	Normal based on		No. of plot	Normal based on		No. of plot	Normal based on	
	6 varieties	5 varieties		6 varieties	5 varieties		6 varieties	5 varieties
1	916	976	21	863	869	41	761	744
2	915	971	22	859	864	42	755	738
3	913	966	23	855	858	43	749	731
4	911	961	24	851	852	44	742	724
5	909	956	25	846	846	45	735	717
6	907	951	26	842	840	46	728	710
7	905	946	27	837	834	47	722	703
8	903	941	28	833	828	48	715	696
9	901	935	29	828	822	49	707	689
10	898	930	30	823	816	50	700	682
11	895	925	31	818	809	51	693	675
12	893	920	32	813	803	52	685	668
13	890	914	33	808	797	53	677	661
14	887	909	34	802	790	54	670	653
15	884	903	35	797	784	55	662	646
16	881	898	36	791	777	56	654	639
17	877	892	37	785	771	57	646	631
18	874	887	38	780	764	58	637	624
19	870	881	39	774	758	59	629	616
20	867	875	40	768	751	60	621	608

[1] It will be noticed that the "normal yield curve" is nearly linear, showing a very steady decrease of fertility from one end of the field to the other. I have also calculated the correlation between the actual yield and the position of the plot as indicated by its serial number. The coefficient of correlation comes out to be r= —0·67 58. This gives a convenient measure of the variation of fertility. If we assume that all the different varieties are equally affected by this variation, then the correlation between any two varieties will also be 0·67 58 but *positive, i.e.*, the correlation between any two varieties is r (ab)= +0·68 approximately. Mr. Sarkar gives (p. 481) the p. e. of Kalamdan as 21·5 and of Early Indrasal as 19·33. Let us take e (a)=e (b)=20 approximately. Using the complete expression for the probable error of mean (a—b), we get $\sqrt{20^2+20^2-2\times 0{\cdot}68\times 20\times 20}=\pm 16{\cdot}0$ approximately, which compares very favourably with the value 14·1 found directly by Mr. Sarkar. Evidently the correlation between Kalamdan and Indrasal is higher than +0·68 but is of the same order.

DIAGRAM 1.


Observed Yield x.....x.....x.
6-Varieties Normal.—.—.—
5-Varieties Normal ——
1100
1000
900
800
700
600
Yield in tolas
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 60
Number of Plot

Subtracting the normal value (*i.e.*, the graduated value) from the observed value of the yield we get the " departure from normal "[1] and expressing it as a percentage of the normal, we obtain the percentage departure. Tables II and III (which correspond to Mr. Sarkar's Table VII, p. 485) give these percentage departures and the means and other constants.

TABLE II.

Percentage departure from the first normal.

No.	Indrasal	No.	Lochai	No.	Dudhsar	No.	No. 26	No.	No. 51	No.	Kalamdan
1	—13·2	2	— 6·3	3	+10·4	4	+18·6	5	+16·3	6	— 4·4
7	—14·6	8	—10·5	9	+ 3·8	10	+11·1	11	+16·8	12	..
13	— 6·7	14	—14·0	15	—1·0	16	+ 2·2	17	+12·3	18	+ 5·3
19	—10·3	20	—18·1	21	—6·7	22	— 3·0	23	+17·0	24	—12·8
25	— 8·4	26	—24·6	27	—1·1	28	— 0·4	29	+19·3	30	+ 0·9
31	—16·3	32	+20·5	33	+2·1	34	+12·5	35	+ 3·8	36	— 6·7
37	—14·0	38	+17·2	39	—0·8	40	+ 2·6	41	+ 9·2	42	+ 4·1
43	—10·3	44	+22·0	45	—5·4	46	+ 8·5	47	+ 4·6	48	— 9·1
49	—13·0	50	+21·1	51	—7·6	52	+ 8·8	53	+ 0·9	54	— 3·0
55	—14·4	56	— 4·4	57	—7 1	58	+ 0·5	59	+ 8·1	60	+ 0·6

TABLE III.

Mean percentage departures, etc.

No.	(1) Variety	(2) Mean percentage departure and corrected prob. error	(3) Standard deviation	(4) Z=M/s	(5) Odds based on Z
1	No. 51	+10·83 ±1·46	6·12	1·77	$>5\times10^3$
2	No. 26	+ 6·14 ±1·54	6·47	0·95	101·0
3	C. P. Lochai . . .	+ 0·29 ±4·09	17·16	0·02	1·10
4	Dudhsar	— 1·34 ±1·29	5·42	0·25	3·19
5	Kalamdan . . .	— 2·51 ±1·31	5·50	0·46	8·76
6	Indrasal	— 12·2 ±0·69	2·90	4·18	$>10^4$

Table III, Col. (2) gives the mean percentage departure with " corrected " probable error (explained below), Col. (3) gives the standard deviation and Col. (4) is " Student's " function Z=M/s (described on p. 99), while Col. (5) gives the odds based on Col. (4) and " Student's " Table.

[1] Mr. Sarkar subtracts the actual value from the normal; his departures are therefore opposite in sign to mine.

The odds are 10,000 to 1 or overwhelmingly against Indrasal and 5,000 to 1 or overwhelmingly in favour of No. 51. The odds are 100 to 1 in favour of No. 26 ; it is therefore fairly certain that No. 26 gives a better yield than the normal. Dudhsar and C. P. Lochai are more or less average, while Kalamdan is probably slightly inferior.

It will be noticed that C. P. Lochai gives a very high standard deviation 17·16, showing abnormal variations. Mr. Sarkar has noted this ; he thinks that it is due to some " accident." I shall come back to this point a little later.

The observed standard deviations given in Col. (3), Table III, are corrected by multiplying them by the factor 1·11 87 (which is the appropriate value for n=10 in Table A above). The corrected probable errors are then obtained by multiplying the " corrected " standard deviations by $\cdot 6745/\sqrt{10}$; they are given in Col. (2), Table III.

We can now proceed to compare any two varieties with the help of the corrected probable errors given in Table III, Col. (2) above. We have presumably got rid of the systematic variations of the external factors, *i.e.*,of the fertility of the land, so that we shall be now justified in using the abbreviated formula $e\,(a-b)=\sqrt{e^2\,(a)+e^2\,(b)}$ for finding the probable error of differences.

Mr. Sarkar has also used a modified form of this formula[1] for constructing his Table VII, but he has not applied the correction for smallness of the size of samples. In the following Table IV, I show the odds calculated by using both the " corrected " and the " uncorrected " standard deviations.

We can also use the percentage departures given in Table II for a direct comparison of any two varieties by the " difference method," using " Student's " Table. I have calculated the odds by this method also and have shown them in Col. (5) of Table IV. The odds are reduced to unity in each case.

TABLE IV.

Varieties compared	Mean percentage difference with prob. error	Odds based on		
		" Uncorrected " prob. error	" Corrected " prob. error	Difference method
(1)	(2)	(3)	(4)	(5)
No. 51 and—				
No. 26 . . .	+ 4·69 ± 2·12	19·62	13·68	9·73
C. P. Lochai . .	+10·54 ± 4·34	28·76	18·80	8·76
Dudhsar . . .	+12·17 ± 1·95	$>10^6$	$7{\cdot}7\times 10^4$	$8{\cdot}5\times 10^2$
Kalamdan . . .	+13·34 ± 1·96	$>10^7$	$5{\cdot}0\times 10^5$	$3{\cdot}3\times 10^3$
Indrasal . . .	+22·95 ± 1·61	$>10^{25}$	$>10^{20}$	$3{\cdot}0\times 10^6$

[1] Mr. Sarkar uses the approximation $\sqrt{2}\left\{\frac{e\,(a)+e\,(b)}{2}\right\}$ This introduces a small error in his results. The abbreviated formula (1) is actually simpler in use, as it avoids the multiplication by $\sqrt{2}$ The p. e. of a difference can be written down in a few seconds with the help of Barlow's Table (or any other Table) of squares.

TABLE IV—*concld.*

Varieties compared	Mean percentage difference with prob. error	Odds based on		
		"Uncorrected" prob. error	"Corrected" prob. error	Difference method
(1)	(2)	(3)	(4)	(5)
No. 26 and—				
C. P. Lochai . .	+ 5·85±4·37	5·40	4·43	5·67
Dudhsar . . .	+ 7·48±2·01	390	164·7	$1·8 \times 10^3$
Kalamdan . . .	+ 8·65±2·03	$1·6 \times 10^3$	502	100
Indrasal . . .	+18·26±1·69	$>10^{15}$	$>10^{11}$	$2·0 \times 10^4$
C. P. Lochai and—				
Dudhsar . . .	+ 1·63±4·29	1·59	1·52	1·52
Kalamdan . . .	+ 2·80±4·30	2·20	2·03	5·13
Indrasal . . .	+12·41±4·15	83	45·10	23·6
Dudhsar and—				
Kalamdan . . .	+ 1·17±1·84	2·17	2·00	2·19
Indrasal . . .	+10·78±1·47	$>10^{10}$	$2·8 \times 10^6$	$2·04 \times 10^3$
Kalamdan and Indrasal .	+ 9·61±1·48	$>10^8$	$>10^5$	$2·18 \times 10^3$

The "uncorrected" probable errors give too high values for the odds and may easily create a false sense of security. The "difference method" appears to give the lowest odds and hence is probably the safest, but the "corrected" probable errors are not likely to lead to serious mistakes.

The construction of the "normal yield curve" for the whole field is admittedly an empirical process. A very careful examination of the raw material is therefore essential. One way of securing this would be to graduate each variety separately and then compare the results to see if there is any general agreement.

Adopting Whittaker's method I get the following expressions for the graduated values.[1] "y" in each case gives the yield in *tolas* and "x" the serial number of the plot.

No. 51	y=11	23·46—6·76	81	x—0·01	64	84 x^2
No. 26	y=10	71·95—8·53	72	x+0·03	17	61 x^2
Dudhsar	y= 9	95·94—6·16	87	x—0·01	08	38 x^2
Kalamdan	y= 9	10·73—2·54	70	x—0·04	08	25 x^2
Indrasal	y= 8	00·73+0·10	46	x—0·08	04	58 x^2
TOTAL .	y=49	02·81—24·0	64	x—0·11	66	44 x^2

[1] I give in an appendix full details of the arithmetical work for one variety, Indrasal.

Dividing by 5, we get

Mean $y = 9\ 80{\cdot}56 - 4{\cdot}80\ 13\ x - 0{\cdot}02\ 33\ 29\ x^2$

The graduated values as well as the departures of the observed values from the graduated values are given in Table V and are plotted in Diagrams 2 and 3. The standard deviations of the departures are also given at the bottom of the columns.

TABLE V.

Departures from normal.

No. 51		No. 26		C. P. Lochai		Dudhsar		Kalamdan		Indrasal	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1089	—32	1038	+42	772	+ 85	977	+31	894	—27	801	—6
1047	— 2	990	+ 8	795	+ 13	940	— 5	874	+19	798	—25
1004	—19	944	—44	813	— 50	901	—26	852	+68	789	+41
959	+41	901	—68	824	—114	862	—57	826	—84	774	+ 6
913	+75	860	—30	829	—194	821	+ 7	798	+32	753	+22
866	—39	822	+80	828	+152	781	+44	766	—28	727	—42
818	+13	786	+ 2	821	+ 93	739	+29	732	+54	694	—19
769	—14	752	+38	808	+ 97	696	— 1	694	—44	656	+16
718	—35	721	+24	789	+ 59	653	—13	654	— 4	613	+ 2
667	+13	692	—52	764	—139	609	— 9	611	+14	563	+ 4
S. D.=34·6		S. D.=48·1		S. D.=107·0		S. D.=28·3		S. D.=44·3		S. D.=23·1	

It will be seen from Diagram 2 that all the different varieties with the one single exception of C. P. Lochai are in satisfactory agreement. The departure curve for C. P. Lochai, as well as its high standard deviation, 107·0, show that it is most probably affected by " accidental " (or sudden and discontinuous) errors. It is obvious that we cannot use it for constructing the field normal. It is too irregular and must be rejected.

We may now combine the 5 concordant varieties and construct the " normal curve." The simplest way of doing this will be to take the arithmetic mean of the 5 component curves. We can obtain the equation for the " normal yield " by simply taking the mean values of the three constants a, b and c. The arithmetic mean has already been given above. The " normal yield " is given in Col. 3 of Table I and is shown as a graph in Diagram 1.

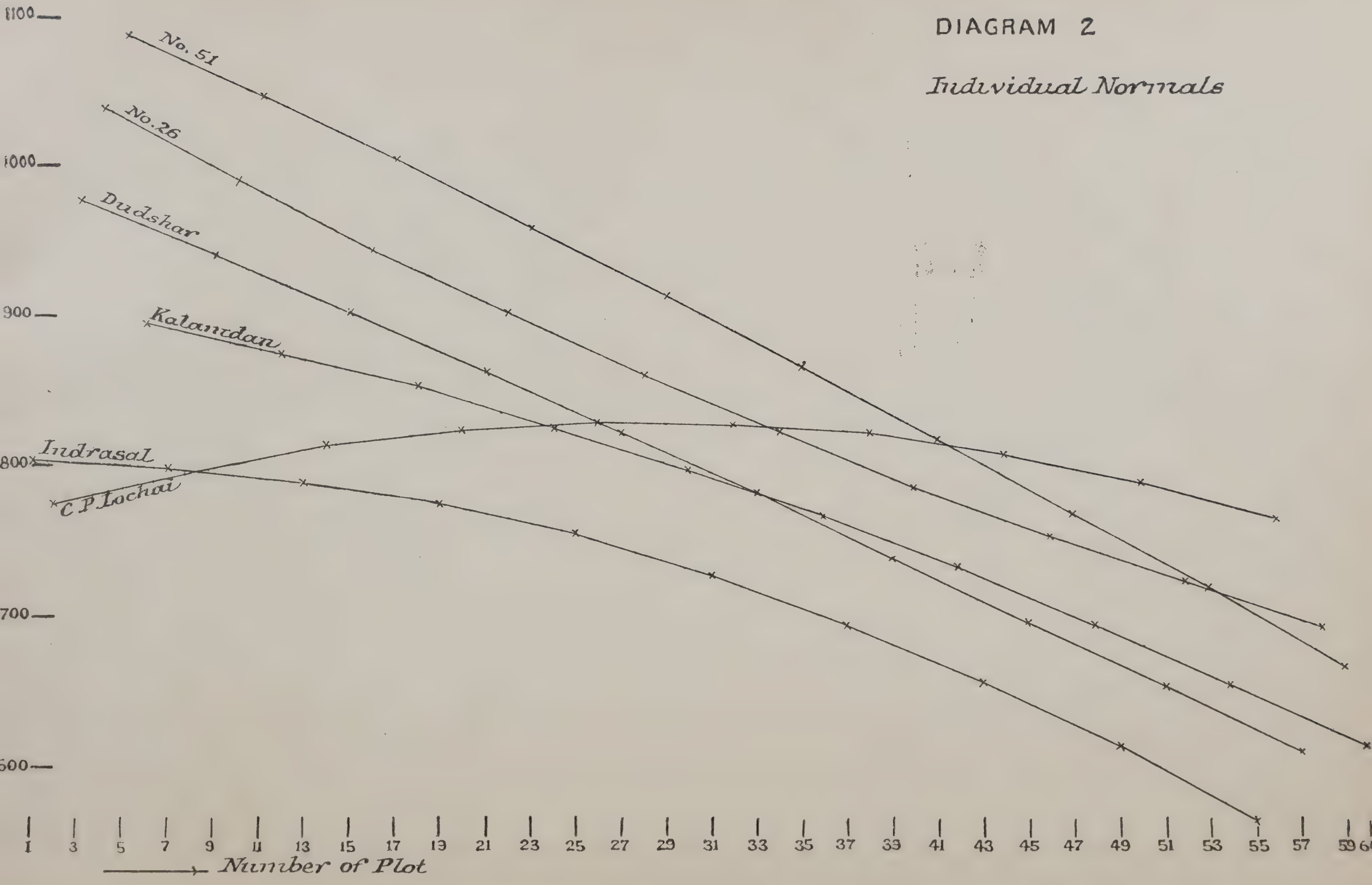


DIAGRAM 2
Individual Normals
1100
1000
900
800
700
600
No. 51
No. 26
Dudshar
Kalamdan
Indrasal
C P Lochai
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59
Number of Plot

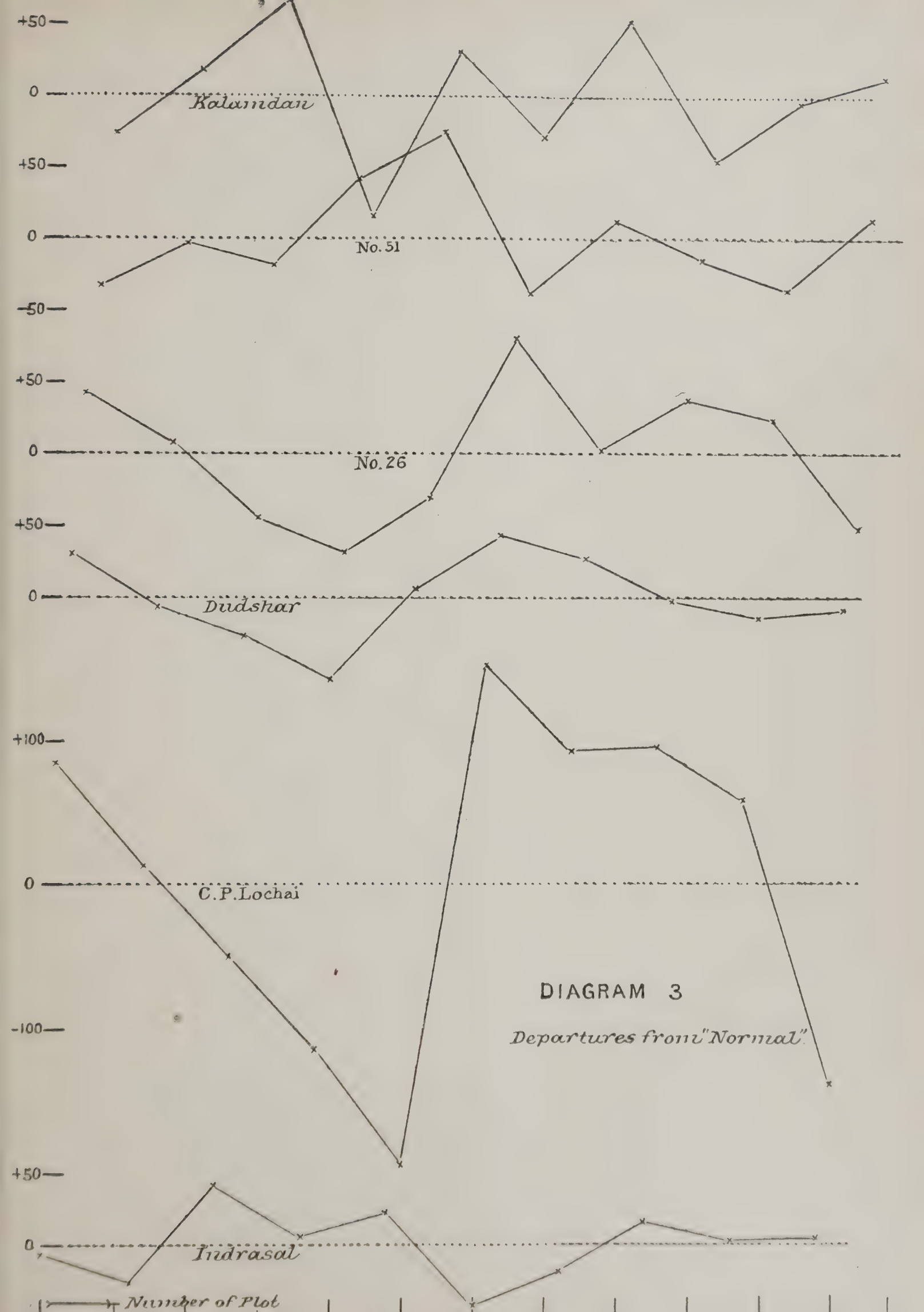


DIAGRAM 3

Departures from "Normal"

Having obtained our " normal " we can now proceed to calculate the percentage departures from normal, mean percentage differences and probability in the same way as described above. Corresponding to Tables II, III and IV we get a new set of Tables VI, VII and VIII which are given below.

TABLE VI.

Percentage departure from the second normal.

No.	No. 51	No.	No. 26	No.	Dudhsar	No.	Kalamdan	No.	Indrasal
5	+10·56	4	+12·38	3	+4·35	6	— 8·83	1	—18·55
11	+12·97	10	+ 7·31	9	..	12	— 2·93	7	—18·18
17	+10·43	16	+ 0·22	15	—3·10	18	+ 3·72	13	— 8·75
23	+16·55	22	— 3·59	21	—7·36	24	—12·91	19	—11·46
29	+20·20	28	+ 0·24	27	—0·72	30	+ 1·72	25	— 8·39
35	+ 5·48	34	+14·18	33	+3·59	36	— 5·02	31	—15·33
41	+11·69	40	+ 4·93	39	+1·32	42	+ 6·50	37	—12·45
47	+ 7·40	46	+11·27	45	—3·07	48	— 6·61	43	— 8·07
53	+ 3·33	52	+11·53	51	—5·19	54	— 0·46	49	—10·74
59	+10·39	58	+ 2·56	57	—4·91	60	+ 2·80	55	—12·38

TABLE VII.

Mean percentage difference.

Variety	Mean percentage departure with corrected P. E.	Corrected standard deviation
No. 51	+10·90 ± 1·13	5·23
No. 26	+ 6·10 ± 1·39	6·51
Dudhsar	— 1·52 ± 0·88	4·12
Kalamdan	— 2·20 ± 1·39	6·53
Indrasal	—12·43 ± 0·87	4·06

TABLE VIII.

(1) Varieties compared	(2) Percentage difference with corrected P. E.	Odds based on: Corrected P. E.	Odds based on: "Difference" method.
No. 51 and—			
No. 26	+ 4·80 ± 1·79	27·45	10·29
Dudhsar	+12·42 ± 1·43	$>4·3\times10^{8}$	$>1·0\times10^{4}$
Kalamdan	+13·10 ± 1·79	$>2·6\times10^{6}$	$<3·4\times10^{3}$
Indrasal	+23·33 ± 1·42	Very large	Very large
No. 26 and—			
Dudhsar	+ 7·62 ± 1·64	$>1·1\times10^{3}$	$>1·9\times10^{3}$
Kalamdan	+ 8·30 ± 1·97	456·5	91·76
Indrasal	+18·53 ± 1·64	Very large	$>2·4\times10^{4}$
Dudhsar and—			
Kalamdan	+ 0·68 ± 1·65	1·57	1·57
Indrasal	+10·91 ± 1·23	$>7·7\times10^{8}$	$>2·7\times10^{3}$
Kalamdan and Indrasal	+10·23 ± 1·64	$>7·8\times10^{4}$	$>3·8\times10^{3}$

We see again that the "difference method" gives the lowest odds. It should be remembered however that the plots compared are in certain cases widely separated, *e.g.*, Indrasal and Kalamdan, where the first plot of Kalamdan is separated from first plot of Indrasal by 4 intervening plots but is actually contiguous to the *second* plot of Indrasal.

The "Sub-plot" Method.

In order that the present method may give reliable results it is obviously necessary that the "normal yield curve" should be a reasonable description of the actual variation of fertility of the field. In fact the reliability of the present method depends entirely on the probability that the normal yield curve is a true description of the actual situation. In order to appreciate the real probability of the results obtained by the present method it is therefore necessary to determine the probability of the normal yield curve.

Now the normal yield curve is built up from the separate individual yield curves which in their turn are obtained from the values of the yield for each individual plot. The probability of the normal yield curve thus ultimately rests on the probability of the yield for each individual plot. It is therefore essential that we should have some basis on which we can determine the probable error of the yield for single plots. This point is of vital importance, but unfortunately in the procedure usually

adopted in agricultural experiments absolutely no way is left for determining the probable error of the yield of single plots.

The only possible basis on which this can be done is to divide each plot into a number of sub-plots and secure the yield from each separate sub-plot. The scheme can be diagrammatically represented as follows :---

a (11)	b (11)	c (11)	..	..	..	a (21)	b (21)	..	..
a (12)	b (12)	c (12)	..	..	..	a (22)	b (22)	..	..
a (13)	b (13)	c (13)	..	..	..	a (23)	b (23)	..	..
a (14)	b (14)	c (14)	..	..	..	a (24)	b (24)	..	..
a (15)	b (15)	c (15)	..	..	..	a (25)	b (25)	..	..
a (1·)	b (1·)	c (1·)	..	..	..	a (2·)	b (2·)	..	..

As at present arranged the yield for the whole plot a (1) is determined integrally. In the method proposed the plot a will be divided into a number of sub-plots a (11), a (12), a (13), a (14) .. .. etc., and the yield for each sub-plot will be determined separately. The total yield for a (1) will then be obtained by adding the yield for all the sub-plots.

The essential point, however, is that this method will enable us to determine the probable error of a (1), a (2), a (3) .. .. . The probability of the graduated yield-curves for a, b, c (*i.e.*, for all the different varieties) can then be found and finally the probability of the normal yield curve itself.

The additional labour involved in the purely agricultural portion of the work is negligible. The only thing necessary will be to mark out the sub-plots a (11), a (12), a (13) .. b (11), b (12), b (13) .. .. etc.

Harvesting, threshing and weighing will however have to be carried out individually for each of the sub-plots a (11), a (12) .. .. .. b (11), b (12) .. .. etc., and will entail a much larger number of measurements. But the additional labour involved will probably be fully justified in view of the additional accuracy and the greater significance of the results which may be secured by this method.

I conclude therefore that *in order to obtain reliable results it is absolutely essential to adopt the above "sub-plot" (or "chess-board pattern") method of laying out the experimental plots.*[1]

Summary of Conclusions.

It may be useful to indicate briefly the chief conclusions of my discussion.

(*a*) It is desirable to adopt, wherever possible, the "direct difference" method for finding the probable error of a mean difference and to use "Student's" Table for finding the probability.

(*b*) Wherever external variations are known to occur, it is desirable to eliminate their effect by considering departures from the "normal."

[1] I have indicated briefly in Appendix III suitable statistical formulæ which may be conveniently used in connection with the "sub-plot" method.

(*c*) In constructing the "normal," as many varieties as possible should be used; and

(*d*) preferably, the results for each variety should be graduated separately and then combined together for constructing the "normal," after elimination of irregular varieties.

(*e*) In finding the probable error from small samples it is desirable to "correct" the observed standard deviations by multiplying them by suitable correcting factors. (A table of correcting factors has been given above.)

(*f*) Statistically speaking, it is absolutely essential to adopt a "sub-plot" method of laying out the field in order to determine the reliability of the "normal" used.

I note with interest that Mr. Sarkar proposes to test different statistical methods in connection with the results of further trials. May I suggest that in doing so he will keep in view the results offered above. Personally I shall be only too glad to give such statistical help as may lay in my power.

I am grateful to Dr. C. W. B. Normand, M.A., D.Sc., Officiating Director-General of Observatories, for drawing my attention to Mr. Sarkar's paper. I am also much indebted to my Assistant Babu Devendranath Chakravarti for arithmetical aid.

Appendix I.

Whittaker's method of smoothing.

Let a (1), a (2), a (3), ... a (n) be the successive yields. We then find the following fundamental constants by straightforward summation.

$M_0 = a(1) + a(2) + a(3) + \ldots + a(n)$

$M = 1.\,a(1) + 2.\,a(2) + \ldots + n.\,a(n)$

$M = 1^2.\,a(1) + 2^2.\,a(2) + \ldots + n^2.\,a(n)$

Arranging the work in tabular form :—

(1)	Yield (2)	(3)	(4)
Number of Indrasal plot = n	= a (n)	n. a (n)	n^2. a (n)
1	7 95	7 95	7 95
2	7 73	15 46	30 92
3	8 30	24 90	74 70
4	7 80	31 20	1 24 80
5	7 75	38 75	1 93 75
6	6 85	41 10	2 46 60
7	6 75	47 25	3 30 75
8	6 72	53 76	4 30 08
9	6 15	55 35	4 98 15
10	5 67	56 70	5 67 00
Sum	71 67	3 72 42	25 04 70

We get $M_0 = 71\ 67$, $M_1 = 3\ 72\ 42$, $M_2 = 25\ 04\ 70$.

From these we next obtain the following constants (remembering $n = 10$).

$$p = \frac{M_0}{n} = \frac{7167}{10} = 716{\cdot}7$$

$$q = \frac{2\,M_1}{n\,(n+1)} = \frac{2 \times 372\ 42}{10 \times 11} = 677{\cdot}09$$

$$r = \frac{6\,M_2}{n\,(n+1)} = \frac{6 \times 25\ 04\ 70}{10 \times 11} = 1\ 36\ 60{\cdot}18\ 18$$

$$s = \frac{6\,(q-p)}{n-1} = \frac{6\,(677{\cdot}09-716{\cdot}7)}{9} = -26{\cdot}40\ 60\ 61$$

$$t = \frac{2[r-(2n+1)\,p]}{n-1} = \frac{2\,[13600{\cdot}1818-21 \times 716{\cdot}7]}{9} = -309{\cdot}00\ 40\ 40$$

From these we get finally—

$$c = \frac{15\,[t-(n+1)\,s]}{(n+2)\,(n-2)} = \frac{15\,[-309{\cdot}00\ 40\ 40+11 \times 26{\cdot}40\ 60\ 61]}{12 \times 8} = -2{\cdot}89\ 64\ 63$$

$$b = s-(n+1)\,c = -26{\cdot}40\ 60\ 61+11 \times 2{\cdot}89\ 64\ 63 = +5{\cdot}45\ 50\ 32$$

and $a = q - \frac{2n+1}{3} \cdot b - \frac{n\,(n+1)}{2} \cdot c = 677{\cdot}09-7 \times 5{\cdot}45\ 50\ 32+55 \times 2{\cdot}89\ 69\ 63+798{\cdot}21.$

The graduated values will then be given by :—

$$y = a+bZ+cZ^2 = 798{\cdot}21+5{\cdot}45\ 50.\ Z-2{\cdot}89\ 64\ 63.\ Z^2$$

where Z refers to the number of Indrasal plots :—1, 2, 3, ... 10.

But these correspond to the serial number x :—1. 7, 13, ... 55. Evidently $Z = \frac{x+5}{6}$.

Substituting this value in the above equation,

$$y = 7\ 98{\cdot}21+5{\cdot}46\ 50\ \frac{(x+5)}{6} - 2{\cdot}89\ 64\ 63\ \frac{(x+5)^2}{6^2}$$

or $y = 8\ 00{\cdot}73+0{\cdot}10\ 46\ x - 0{\cdot}08\ 01\ 58\ x^2$

the value quoted above.

As I have already pointed out, we want a very smooth fit. I therefore stop here and do not try to improve the fit by the method described by Whittaker.

Appendix II.

The mean difference for graduated values can be obtained very easily with the help of simple algebraic expressions

Let $y_1 = a_1+b_1\,x+c_1\,x^2$ and $y_2 = a_2+b_2\,x+c_2\,x^2$ be any two graduated yield-curves where "y" gives the yield and "x" the serial number of the plot. Then $Z = y_1-y_2 = A+B\,x+C\,x^2$ where $A = a_1-a_2$, $B = b_1-b_2$ and $C = c_1-c$.

It can be easily shown that the mean value of the difference

$$Z=A+B.\ \frac{1}{n}\ S\ (x)+C.\ \frac{1}{n}.\ S\ (x^2)$$

and the square of the standard deviation of Z,

$$s^2\ (z)=\left[\frac{1}{n}.\ S\ (x^2)-\left\{\frac{1}{n}.\ S\ (x)\right\}^2\right]\ B^2$$
$$+\left[\frac{1}{n}S\ (x^3)-\frac{1}{n^2}\ S\ (x)\ S\ (x^2)\right]\ BC$$
$$+\left[\frac{1}{n}\ S\ (x^4)-\left\{\frac{1}{n}\ S\ (x^2)\right\}^2\right]\ C^2$$

where S denotes a summation for the different values of n.

Now in the present type of problem x will usually take the form a+(n—1) d where, "a"= general serial number of the first plot, "n"=the number of plots sown with each variety and "d"= number of different varieties. Forexample, in the illustration given by Mr. Sarkar n=10 and d=6. For Indrasal a= 1, and we get 1, 7, 13 .. .. 55 for successive values of x.

Thus putting x=a+(n—1) d, we get

$$\frac{1}{n}\ S\ (x^2)-\ \left\{\frac{1}{n}\ S\ (x)\right\}^2=\frac{n^2-1}{12}d^2$$

$$\frac{1}{n}S\ (x^3)-\ \ \frac{1}{n^2}\ S\ (x).\ S\ (x^2)=\ \frac{n^2-1}{12}\ .d^2\left\{2a+(n-1)\ d\right\}$$

$$\frac{1}{n}\ S\ (x^4)-\left\{\frac{1}{n}S\ (x^2)\right\}^2=\frac{n^2-1}{3}\ .\ d^2\left\{a^2+(n-1)\ a.\ d+\ \frac{16n^2-30n+1}{60}\right\}$$

from which Z and s (z) can be easily found.

Appendix III.

Goodness of fit of the "normal curve."

We may apply the X^2 test for "goodness of fit" devised by Karl Pearson. Let a (1), a (2), a (3) .. .. , in general, a (n) be the yield of the nth a—plot, let a(O)=mean yield of all a. plots taken together and s^2 (a)=the square of the standard deviation of all a. plots irrespective of the position in the field. Let p be the number of sub-plots into which *each* plot is divided and let n=total number of a. plots altogether.

Then the correlation ratio η (of yield on position of the plot) is defined by the equation

$$\eta^2=\frac{p}{n}.\ S\left\{\frac{(n)-a\ (o)}{s^2\ (a)}\right\}^2$$

where S denotes a summation for all n values of a.

Let a^1 (n) be the graduated value corresponding to observed value a (n),

Karl Pearson has suggested the following value* for X^2:—

$$X^2=p.\ \frac{S\left\{a\ (n)-a^1\ (n)\right\}^2}{(1-\eta^2).\ s^2\ (a)}$$

The value of X^2 can be easily calculated with the help of the above two formulæ.

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* "On the application of 'Goodness of Fit' Tables to test Regression Curves and Theoretical Curves used to describe Observational or Experimental Data." *Biometrika*, XI (1915-1917), 239-261.

Tables are available for finding the probability of the fit from observed values of X^2, the quantity defined above.*

It should be remembered that here the total number of independent variables is n in the present case and hence the probability Tables for X^2 should be looked up under $n^1 = n+1$.

Having obtained the probability for each separate curve we can assign suitable statistical weights to the different curves in constructing the normal. The probability of the normal can then be found either from the constants of the component curves or directly from the correlation ratio of the yield on position in the field for all plots taken together. In the absence of actual material I am unable to give a numerical illustration.

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* *Biometrika*, I (1903), 155-163, reprinted as Table XII, p. 26, *Tables for Statisticians and Biometricians.*

FURNACES FOR THE MANUFACTURE OF JAGGERY OR GUR

BY

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In Burma, the area under sugarcane has more than doubled itself within the last 10 years and, as a result of this, the enormous amount of timber consumed in the furnaces in the province has forced the Forest Department to restrict the supply of fuel.

The cane-grower here ordinarily uses fuel 5–8 inches in diameter and 6–9 feet long and costing from Rs. 1-8 to Rs. 3 per cartload of approximately 1,000 lb.

One of the greatest problems, therefore, in the sugarcane districts is the supply of fuel, and for the last 18 months the author and his staff have devoted much time to the designing of a furnace which would be able to burn the megass or crushed cane and at the same time evaporate the juice without the addition of any wood fuel.

In the experiments hereafter related none of the leaves or trash was burnt but megass only, thus releasing a certain quantity of valuable manure which can be ploughed into the land, although it is usually set on fire before ploughing.

This year in the Yamethin District near Pyinmana which is the centre of the most important cane-growing district in Burma, two experimental furnaces were erected and the object aimed at was to produce a furnace which would not differ too greatly from the Burmese furnaces to be popular with the growers and at the same time which would effect a saving of fuel and time.

1. The Ordinary Burmese Furnace.

This consists of a pit 6 feet long by 3 feet broad by 3 feet deep, and at one end of this a tunnel about 18–24 inches in diameter is started for the fire-box and continued for a distance of about 20 feet, holes being cut in the roof for the placing of pans as shown in Fig. 1. These pans are usually about 45 inches in diameter and 15 inches deep at the centre and hold 32 gallons or 8 kerosine tins of juice.

No chimney is usually built but if so it is never more than 2 or 3 feet high, and logs about 6 inches in diameter and 6 feet long are always burnt.

This furnace is also to be seen partly excavated and partly built with bricks.

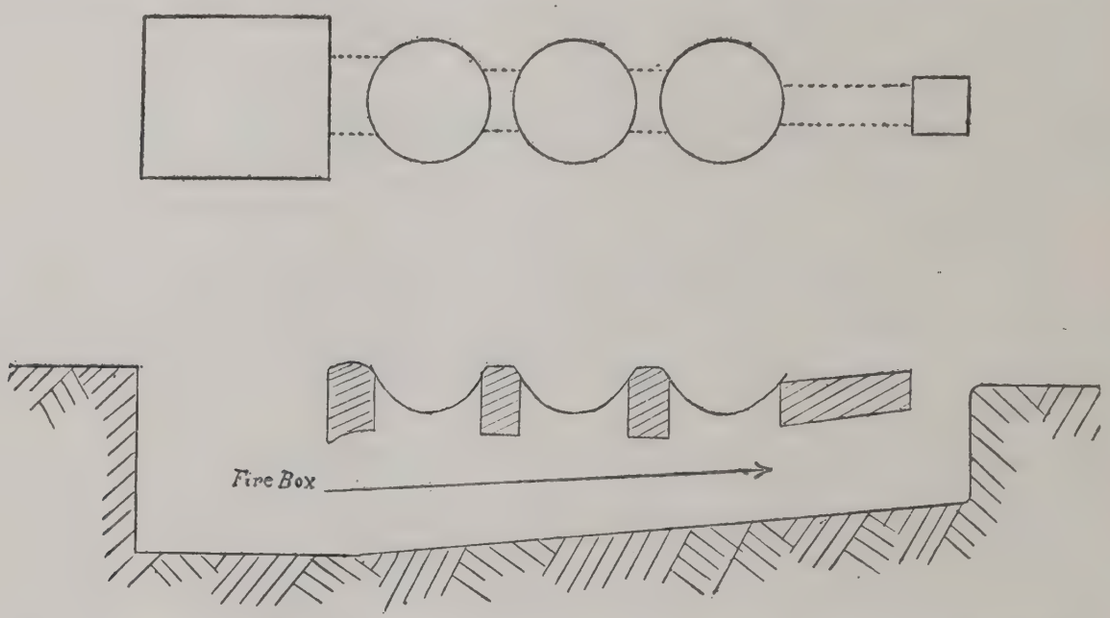

Fig. 1. Ordinary Burmese furnace (without fire-bars). Scale, $\frac{1}{8}$ inch = 1 foot roughly.

This furnace is most inefficient.

(*a*) As no fire-bars are provided the supply of air is not sufficient for complete combustion, and the fire-box gets choked up with partly consumed fuel and requires cleaning out very often.

(*b*) No chimney is provided, therefore draught is small with the result that the fire is not drawn through the flue properly.

(*c*) The megass is not usually burnt at all in these furnaces but thrown away. The figures regarding fuel consumption, etc., of this furnace are as shown under.

TABLE I.

Type of furnace	Variety of cane	No. of		Weight of				Outturn of megass		No. of hours boiled	Fuel used	
		Canes	Tins of juice	Cane	Juice	Jaggery	Calculated available megass	Green	Fit for burning		Megass	Timber
				lb.	lb.	lb.	lb.	lb.	lb.			lb.
Burmese Ordinary	Pyinmana	3,750	166	11,878	6,958	666	4,920	3,567	2,676	16 hrs.	nil	6,000

2. The Improved Local Furnace.

This is very similar to the local furnace except that—

(*a*) It has more brickwork to raise it, thus allowing for an ashpit.

(*b*) Fire-bars are fitted, usually old cart axles.

Ordinary Burmese Dugout Furnace.

(*c*) Fire-doors are fitted.
(*d*) Chimney of 6–15 feet is added.

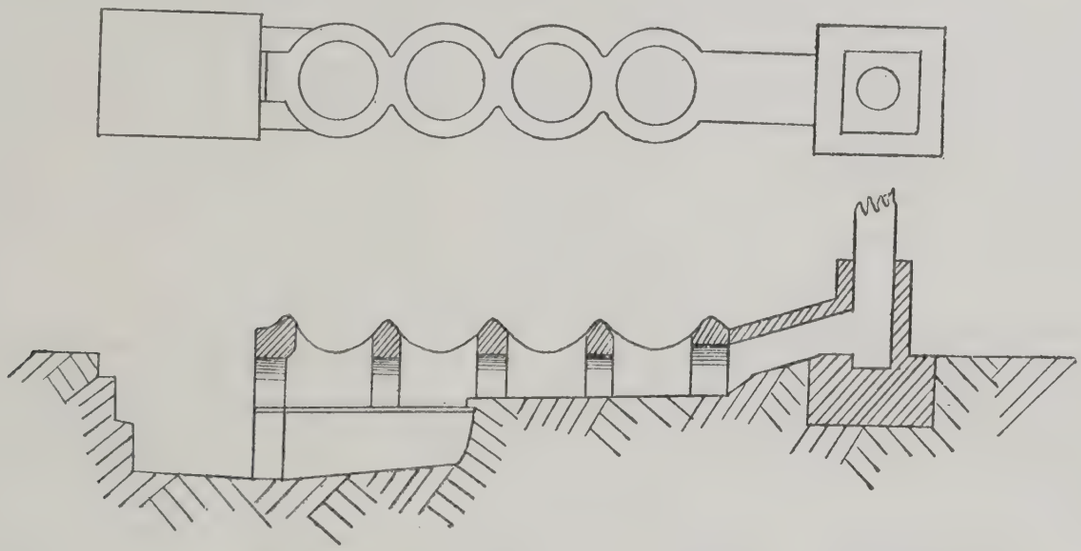

Fig. 2. Improved Burmese furnace with fire-bars.
Scale, $\frac{1}{10}$ inch = 1 foot roughly.

The above furnace is much more efficient but has the following faults —

(*a*) Fire-box area about 16 sq. feet.
(*b*) Large timber has still to be burnt in addition to burning all available megass.
(*c*) A great amount of heat is lost owing to the flues being straight through and very large. The draught from the chimney draws most of the fire past the pans and too much heat escapes up the chimney.
(*d*) The fireman finds it very difficult to stay near the fire-door on account of the great heat thrown out.
(*e*) The combustion is not complete owing to the flues, fire-box, etc., not being correctly proportioned.
(*f*) Large quantities of ash are formed.
(*g*) Fire is not easily shut down at night when boiling is finished ; therefore, large quantities of water have to be carried and the pans filled up to prevent cracking. The figures for the furnace are as follows :—

Type of furnace	Variety of cane	No. of		Weight of				Outturn of megass		No. of hours boiled	Fuel used	
		Canes	Tins of juice	Cane	Juice	Jaggery	Calculated available megass	Green or wet	Fit for burning		Megass	Wood
				lb.	lb.	lb.	lb.	lb.	lb.	hrs.min.	lb.	lb.
Improved Burmese	Pyinmana		235	16,314	9,880	1,444	7,434	4,390	3,303	16 12	2,307	2,362
			124	8,927	5,208	637	3,719	2,697	2,063	14 54	nil	3,545
			174·5	12,620·5	7,544	1,040·5	5,576·5	3,543	2,683	15 33	1,250	2,953

It will be seen that this furnace effects a saving of approximately four cartloads of timber per day.

3. Improved Furnace, Straight Type, known as "Burma Furnace."

This is a modification of the local improved furnace, but with flues and fire-box, etc., more carefully proportioned and fitted with baffle plates to direct the hot gases against pan bottoms.

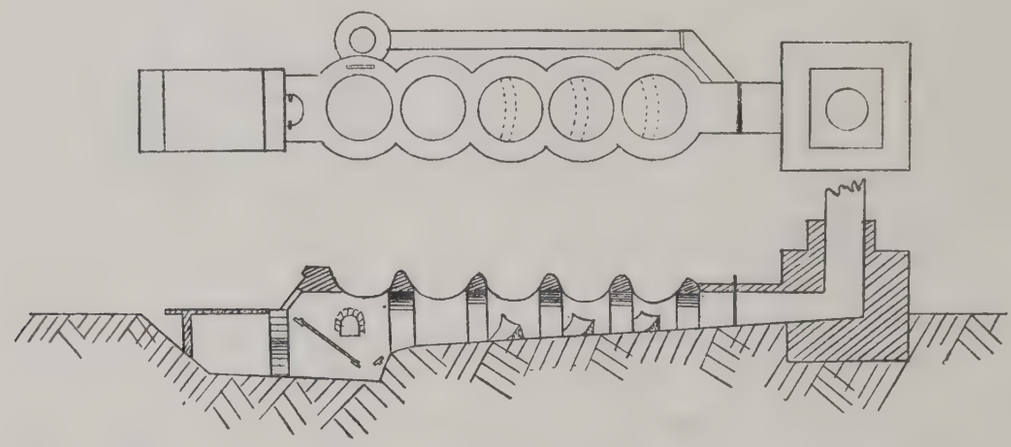

Fig. 3. Improved megass burning furnace designed by the Agricultural Department. Scale, $\frac{1}{12}$ inch = 1 foot roughly.

The fire-box in this furnace is designed after the fashion of megass-burning furnaces in use in Java and America. The fire-bars are similar to those used in paddy husk furnaces and are 3 feet long, 6 inches wide and $\frac{3}{4}$ inch thick with a strengthening rib running down the centre of each. The perforation in these fire-bars is shown below.

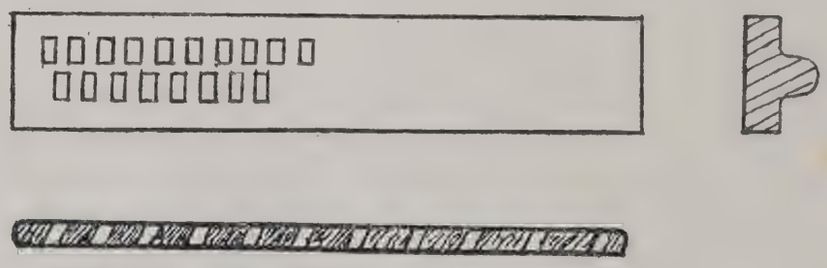

Fig. 4.

Five of these are used in the fire-box and four are placed at an angle of 45° to the horizontal, the bottom of the bars being about 9-10 inches from the ground to allow clearing ashes. The fifth bar is placed across the fire-box at the bottom of the bars as shown. The actual fire-box area is thus only 6 sq. feet.

As it is not possible in such small furnaces to feed megass from overhead, as there is not sufficient drop to allow it to fall on the bars, the feeding door is placed

Improved Departmental Long Furnace.

Return Type Furnace, General View.

at right angles to the slope of the bars and a platform is placed here on which the megass is laid and when required it is easily pushed into the furnace with a short pronged fork.

Specially shaped baffle plates are fitted under each pan to direct the hot gases against the pan bottoms, and the ashpit opening is completely closed with an iron plate which has adjustable air inlets as shown in Fig 5.

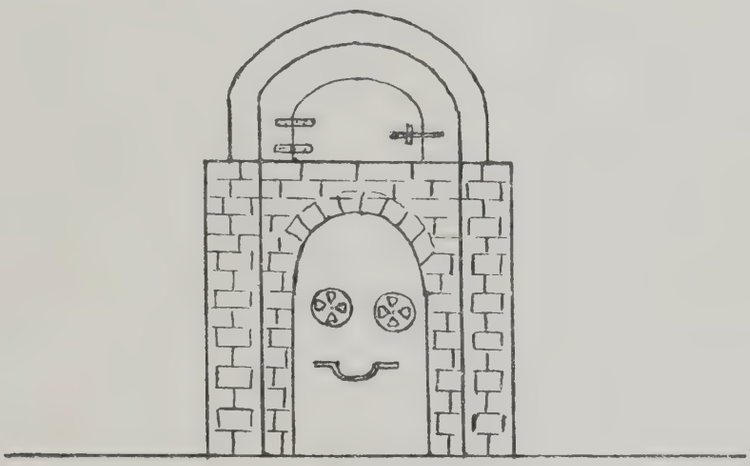

Fig. 5.

This is to shut out all cold air and only allow in sufficient air as is required to complete the combustion. Before the flue enters the chimney there is also a damper fitted to enable the draught to be regulated and at the same time to damp down the fire at night, so that practically only the pan directly over the fire-box has to be filled with water.

This furnace in practice was found to require 1–1½ cartloads of timber per day in addition to megass, but there is a saving of 4½–5 carts a day over the Burmese type of furnace.

For finishing the *jaggery* a small pan is set at the side of the fire-box with a damper at the fire-box and another where the auxiliary flue enters the main flue. The second damper is to shut out air from spoiling the draught when the finishing pan is lifted off.

The two dampers work simultaneously as they are interconnected by an overhead wire running over small pulleys.

Two examples of the superiority of this furnace over the improved Burma furnaces may be taken.

(1) Maung Tun E, near Lewe, had one of these departmental furnaces erected this year, using the same number of pans as he used with his Burmese furnace. The result is that his crusher, which previously gave ample juice to keep his furnace going continuously, is now no longer able to do so. His boilers, therefore, fill up all the pans, evaporate the juice, then go to sleep for about 2 hours until more juice is ready. In this case the departmental furnace would be able to keep two crushers going, *i.e.*, about 140 gallons juice per hour, and this without an ashpit air regulator.

(2) One U E Baw, Thugyi of Tedaung village, who fed his megass very carefully was able to boil without any timber except a little used to kindle his fire.

The figures for this long type of furnace are as shown under.

Type of furnace	Variety of cane	No. of		Weight of				Actual megass		No. of hours boiled	Fuel used		Remarks
		Canes	Tins of juice	Cane	Juice	Jaggery	Calculated available megass	Green or wet	Dry or fit for burning		Megass	Timber	
				lb.	lb	lb.	lb.	lb.	lb.	hrs.	lb.		
Long Improved.	Pyinmana .	615	21	1,388	683	129	705	494	418	2	485	nil	Extra megass was available, so this was used in place of timber.
	,, .	3,600	160	10,250	5,280	1,053	4,970	2,512	1,826	9	1,900		
	Pyinmana mixed with Thaton.	3,560	160	10,236	5,280	920	4,956	3,868	2,460	10	2,662		

4. Improved Furnace, Return Type.

The most efficient type of furnace yet designed, however, is as shown below. This is of the return type and is called by the Burmans "Lay Bwint Saing," meaning "cluster of four flowers."

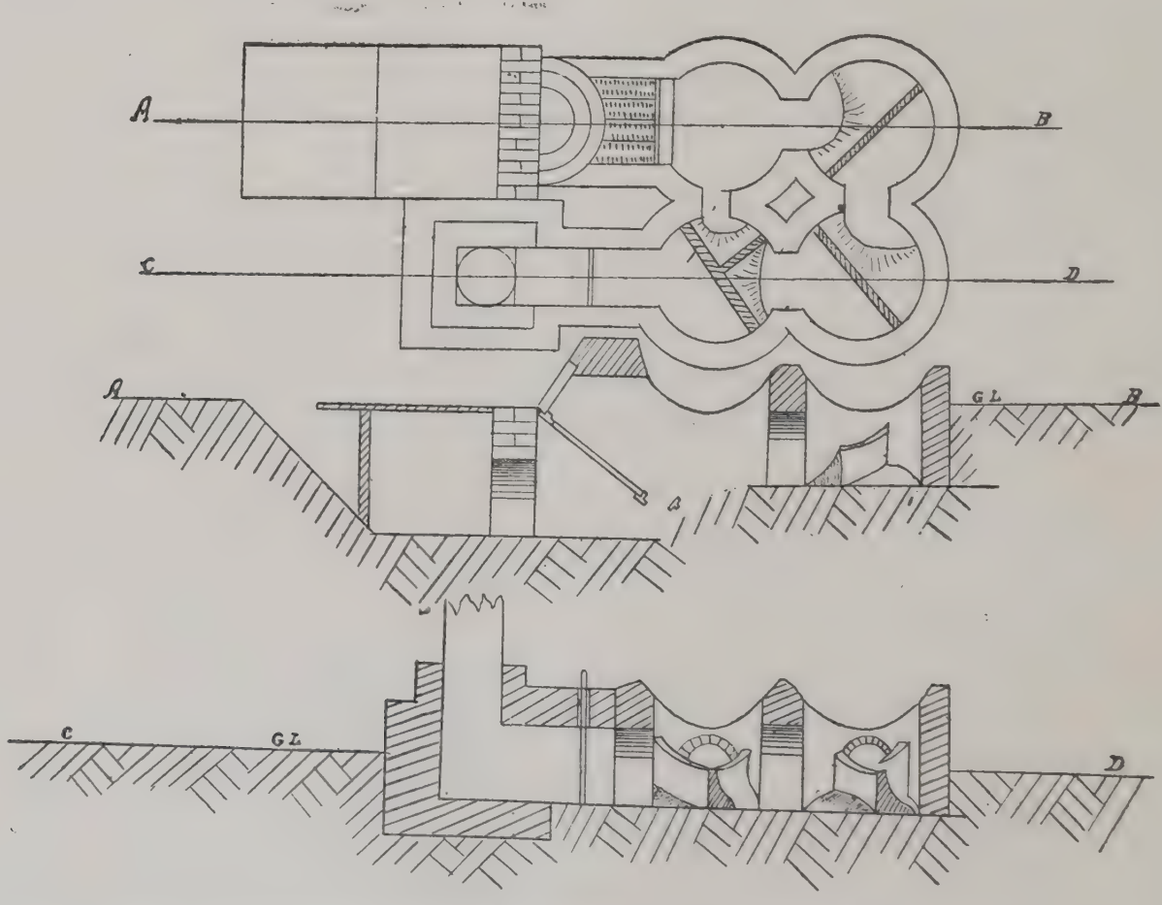

Fig. 6. Return type furnace for megass burning designed by the Agricultural Department. Scale, $\frac{1}{6}$ inch = 1 foot roughly.

Return Type Furnace.

Fire-box of Return Type Furnace.

This furnace is as shown above and has a grate area of 6 sq. feet. The fire-box is similar to that in the long furnace and there is also a damper in the flue between the last pan and chimney.

There is also a small bypass flue from the fire-box to the last pan to enable all the pans to be kept boiling. The finishing furnace is a small additional one as shown in Fig. 7 which also burns megass.

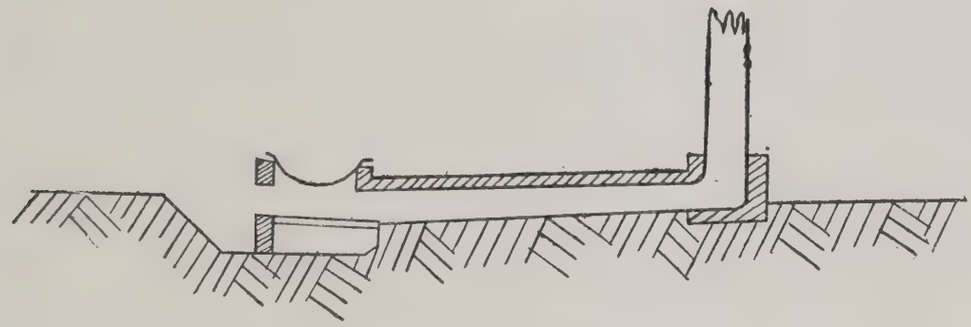

Fig. 7.

In one experiment with this furnace there was left over an excess of 135 lb. megass per hour after evaporating the juice obtained, but this was due to the cane used having a fairly large fibre content and being Java and Toungoo cane the megass of which is harder.

In every case, however, by careful stoking the amount of megass obtained from crushing the cane exceeded the amount used for firing the furnace and the results obtained were as follows :—

Type of furnace	Variety of cane	No. of		Weight of				Actual megass		No. of hours boiled	Fuel used		Remarks
		Canes	Tins of juice	Cane	Juice	Jaggery	Calculated available megass	Green or wet	Dry or fit for burning		Megass	Timber	
				lb.	lb.	lb.	lb.	lb.	lb.	hr. m.	lb.		
Short Improved	Pyinmana	879	30	1,983	975	185	1,008	705	596	2	325	nil	
		2,230	76½	4,810	2,524·5	564	2,285	1,823	1,593	7 25	1,530		
		2,361	66	4,340	2,178	437	2,162	1,680	1,289	8	1,278		

Next cane season further experiments will be carried out with a view to further improvements in the furnace already designed.

The illustrations accompanying this article will give one a good idea of the general appearance of the different furnaces. (Plates VI—VIII.)

SELECTED ARTICLES

LIVESTOCK IMPROVEMENT IN ENGLAND AND WALES IN 1923-24.*

The reasons for the introduction of the Livestock Improvement Scheme in 1914, its object and the lines on which it operates have been set out so fully and often in the Journal and elsewhere as to need but brief recapitulation here.

At the outset it was realized that the funds available for the purposes of the scheme in England and Wales precluded any ambitious attempt at the direct provision by the Government of high-class sires required for use in the grading up of inferior farm stock, even had this been practicable or advisable.

The scheme was, therefore, framed more as an educational measure with the object of showing, by practical demonstration throughout the country, the importance and value of care in the selection and use of good pedigree sires and the direct gain resulting from the application of knowledge obtained from taking milk records and managing dairy herds in a more systematic and economic manner.

For these purposes annual grants are made to bull, boar and heavy horse societies which undertake the provision of approved pure-bred sires for the use of their members and to milk recording societies operating under the scheme.

That the objects aimed at are being achieved is indicated by the annual increase in the number of sires subsidised and the growing interest in and development of the milk recording movement as shown in the tables herewith.

Apart from the direct benefit accruing to the agriculture of the country by reason of the grading up of inferior stock through the instrumentality of the scheme—the focussing of attention on livestock improvement and the association of the Ministry's Livestock Officers with farmers and small holders in their several districts has had some influence, though indirect, in stimulating interest in breeding, in increasing the number of breeders and users of pure-bred cattle and pigs, and in creating a bigger demand for suitable sires amongst people not directly concerned with the scheme.

Bulls. The total number of bulls actually located for service during the year ended 31st March, 1924 (*i.e.*, continued from previous years with renewed grants or provided for fresh districts during the year), was 978, an increase of 31 on the preceding year.

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* Reprinted from *Jour Min. Agri.*, XXXI, No. 6.

BULL SCHEME.

(*Showing the number of bulls subsidised during the past 10 years.*)

Year	Societies	Individuals	Total No. of bulls
1st April to 31st March—			
1914-15*	369	43	497
1915-16	489	28	633
1916-17	543	15	659
1917-18	578	14	710
1918-19	604	7	721
1919-20	568	6	675
1920-21	561	6	668
1921-22	726	3	847
1922-23	831	1	947
1923-24	840	1	978

* Including the period 1st February, 1914—31st March, 1914.

This increase, though not large, is satisfactory in view of the restrictions on movement of stock in force during a large portion of the year owing to the prevalence of foot-and-mouth disease. In districts not so hampered the Ministry's Livestock Officers report very favourably on the progress of the scheme and the marked improvement in the young stock where premium bulls have been in use for some time. It is satisfactory to note the general and continued success of premium sires and their progeny at sales and shows. One of the Ministry's Livestock Officers reports that stock by premium bulls have been successfully shown at every show in his district, and at one of these shows every first prize was won by animals which were sired by premium bulls. In another instance twelve animals under two years old, sired by a premium bull, secured the highest average at the market on that day, and as a result of this success four new members joined the society in order to have the benefit of using this sire. Another of the Ministry's Livestock Officers recently attended a meeting of small holders for the purpose of explaining the advantages of the scheme, and at the close of the meeting eight of the number present guaranteed to advance £10 apiece to start a society and buy a pedigree bull. This decision was partly attributable to the fact that two farmers present at the meeting had seen for themselves the improvement resulting from work of another society in the district, and emphasizes the value to agriculturists of practice over precept.

In some dairying districts, even where calves are reared in considerable numbers, there is still much leeway to be made up. The high prices still commanded (and likely to be) for suitable bulls of dairy strain may partly account for this, and continued effort is necessary to convince such breeders that it is poor economy to continue using nondescript sires about whose breeding little or nothing is known.

There was again a drop in the prices of bulls, other than those of dairy type, purchased during the year under review, and the average price of all the bulls provided was consequently lowered. The following table shows the number of bulls of each breed subsidised and the average cost for the first year and last two years of the scheme :—

NUMBERS AND PRICES OF BULLS OF EACH BREED.

Breed	1914-15		1922-23		1923-24	
	No.	Average cost	No.	Average cost	No.	Average cost
		£ s. d.		£ s. d.		£ s. d.
British Friesian	..	..	6	77 15 8	5	74 16 0
Devon	16	40 17 6	90	59 10 3	106	57 16 0
Guernsey	..	..	7	53 9 3	12	51 10 0
Hereford	63	33 7 6	84	58 3 4	100	50 19 0
Lincoln Red	33	31 10 0	94	63 14 11	101	55 11 0
Red Pole	..	..	1	78 15 0	..	..
Shorthorn	337	37 17 0	553	64 16 3	573	57 10 0
South Devon	6	36 11 6	17	58 11 6	15	47 5 0
Welsh Black	35	29 9 0	64	52 2 11	62	52 1 0
Other Breeds	7	29 4 6	..	..	..	..
All Breeds	497	36 0 0	916	62 11 9	974*	56 3 0

* 978 bulls were located, but grants in respect of 4 were in suspense at the end of the year.

As was the case in the preceding year the service fees varied from 2*s.* 6*d.* to 10*s.* 6*d.* It will be seen from the subjoined table that there was again a substantial increase in the number of bulls serving at 5*s.*, but the number serving at a higher fee remained about the same (*i.e.*, 277 compared with 271 in the previous year). The average service fee for all the bulls was 5*s.* 3*d.*

SERVICE FEES.

Year	2/6	3/	3/6	4/	4/6	5/	5/6	6/	6/6	7/	7/6	8/	8/6	9/	10/	Over 10/
1914-15 .	265	57	41	42	3	88	..	..	..	..	1	..	..	..	..	..
1922-23 .	50	40	28	84	10	430	3	53	2	10	141	7	8	2	45	6
1923-24 .	51	46	25	71	9	491	2	84	2	12	126	6	7	1	26	5

Boars. There was a satisfactory increase in the number of boars available during the year ended 31st March, 1924 (*i.e.*, continued from previous years with renewed grants or located in fresh districts during the year), the number being 638 as compared with 569 in the preceding year. The difficulty of forming Boar Societies is apparent in the fact that of the 638 boars available, 550 were provided by individual owners.

BOAR SCHEME.

(*Showing the number of boars subsidised during the past 10 years.*)

Year*	Societies	Individuals	Total No. of boars
1st April to 31st March—			
1914-15	115	..	115
1915-16	180	..	193
1916-17	186	15	216
1917-18	172	92	264
1918-19	156	167	350
1919-20	120	225	399
1920-21	135	285	441
1921-22	113	416	550
1922-23	93	451	569
1923-24	78	541	638

* Including the period 1st February, 1914—31st March, 1914.

In several districts more applications for premium boars were received than could be met from the number of grants available. In other districts a strong preference for a local type of pig, not recognized as a distinct and established breed, has prevented the fullest use being made of the scheme. In some such districts efforts are being

made to register and form herd books, and to secure recognition from the Ministry for the purpose of the Boar Scheme. In this connection it may be noted that the Ministry has recently, after consultation with its Advisory Livestock Committee, extended this recognition to the Welsh pig.

As in the case of bulls, premium boars and their progeny have attained general success at sales and shows, the natural result of the improvement which has taken place in districts which have been served by premium boars for some years.

Increasing interest has recently been shown in the production of the most suitable type of pig for bacon factories, and efforts are being made to meet the requirements of local factories in this respect by encouraging the most suitable type of sires.

It will be seen from the following table that the average price of the boars located under the scheme during the year under review was £14. 6*s*. 2*d*., which was slightly lower than the previous year's average, *viz*., £15. 0*s*. 4*d*. The most popular breeds at present are the Large White, Large Black and Middle White.

NUMBERS AND AVERAGE PRICES OF BOARS OF EACH BREED.

Breed	1914-15		1922-23		1923-24	
	No.	Average price	No.	Average price	No.	Average price
		£ *s*. *d*.		£ *s*. *d*.		£ *s*. *d*.
Berks	10	8 0 0	11	18 2 3	10	17 1 9
Cumberland	..	..	30	16 5 0	29	14 5 3
Essex	..	..	4	23 7 6	5	19 9 9
Glos. Old Spot	7	7 1 0	37	21 8 0	32	15 8 3
Large Black	18	7 5 6	141	14 12 7	138	13 4 4
Large White	64	7 3 0	199	13 13 10	250	14 11 9
Lincoln Curly Coat	4	8 4 6	31	12 3 10	35	11 16 10
Middle White	12	6 17 0	77	15 11 7	98	14 16 9
Large White Ulster	..	..	2	16 0 0	6	16 6 8
Tamworth	..	..	1	20 0 0	2	18 18 6
Wessex Saddleback	..	..	13	16 2 3	14	14 12 6
All Breeds	115	7 5 3	546	15 0 4	619*	14 6 2

* 638 boars were located, but grants in respect of 19 were in suspense at the end of the year.

The service fees varied from 2*s.* 6*d.* to 10*s.* Considerably more than one-half the boars served at a fee of 5*s.*, while a third of the remainder served at 7*s.* 6*d.* The average fee for all the boars was 5*s.* 5*d.*, a trifle lower than in the previous year.

SERVICE FEES.

Year	2/	2/6	3/	3/6	4/	4/6	5/	5/6	6/	6/6	7/	7/6	8/	8/6	10/	Over 10/
1914-15	21	62	10	5	6	..	2	..	..	..	..	..	..	..	..	..
1922-23	..	7	12	13	37	5	300	..	51	4	2	99	..	4	13	1
1923-24	..	9	9	12	44	1	368	1	58	2	4	104	..	2	5	..

Milk recording. No part of the Livestock Scheme has made more satisfactory progress than milk recording. Notwithstanding the many serious obstacles arising out of the abnormal conditions prevailing during the first five or six years of the operation of the scheme, the movement has continued to spread until at the present time practically every county in England and Wales has its own recording society or societies, and no district is outside the radius of one or other of these societies. During the year under review 416 new members, owning 10,000 cows, have been enrolled, and in view of the hampering restrictions consequent on the serious outbreaks of foot-and-mouth disease over a large part of England and Wales, this increase may be considered satisfactory. The following table shows the growth of the movement since its commencement :—

Year*	Societies	Members	Herds	Cows
1st April to 31st March—				
1914-15	16	264	306	7,331
1915-16	20	350	398	9,811
1916-17	22	441	495	12,950
1917-18	25	503	555	14,404
1st October to 30th September—				
1917-18	27	639	708	19,793
1918-19	38	1,191	1,332	37,880
1919-20	46	2,075	2,312	61,323
1920-21	52	3,328	3,664	97,903
1921-22	55	3,949	4,362	117,023
1922-23	55	4,365	4,767	127,151

* Prior to 1st October 1917, there was no uniform year for societies.

Average yield of herds recorded. The annual returns furnished by the 55 societies for the recording year ended 1st October, 1923, show that of the 127,151 cows and heifers recorded, 54 per cent. were cows which had been retained in the herds for the full year, and that the average yield of these 68,349 cows was approximately 7,000 lb., an appreciable increase over the averages of previous years.

Many societies averaged considerably more; for instance, the Hampshire Society with 3,251 full-year cows averaged 7,601 lb., and the Essex Society, which for the year ended October, 1918, had only 407 full-year cows yielding on an average 6,531 lb., has shown remarkable development, having had in the last milk-recording year 4,388 full-year cows whose average yield was 7,499 lb., a tenfold increase in membership and of approximately 1,000 lb. in the average yield of the cows.

When the milk-recording movement was initiated by the Ministry the thousand-gallon cow was talked about and sometimes got into print, and though the object of the scheme is not to encourage the production of phenomenal milk yielders, it may be of interest to record that last year 125 herds—not cows—averaged 10,000 lb. per cow or over : good evidence of the value of milk recording and of the results obtained by careful weeding out, selection and breeding.

The following statement compares the average annual yield of (1) all cows and heifers recorded, and (2) of the cows recorded for the full year for each year since the uniform milk-recording year was fixed :—

Year	No. of societies	Particulars of all cows and heifers recorded			Particulars of cows recorded for full year			
		No. of cows and heifers	Total yield	Average yield	No. of cows	Percentage of Total cows	Total yield	Average yield
1st October to 1st October			gal.	gal.			gal.	gal.
1917-18 . .	27	19,793	8,426,958	426	8,775	44	5,255,923	599
1918-19 . .	38	37,880	16,204,941	450	17,989	47	10,543,516	579
1919-20 . .	46	61,323	29,344,887	479	27,266	44	17,363,347	637
1920-21 . .	52	97,903	48,512,380	495	48,248	49	30,892,620	640
1921-22 . .	55	117,023	60,463,617	517	63,318	54	41,208,073	651
1922-23 . .	55	127,151	67,904,224	534	68,349	54	46,956,565	687

While the total average yield continued to improve steadily, a much more marked advance is shown in individual herds as a direct result of the more systematic and economic management following the adoption of milk-recording. As an instance of this, in the returns for 33 of the herds (of over 20 cows) of one society which have been recorded from 1917-18 to 1922-23, there was an average increase in the yield per cow of full-year cows of 92 gallons. The maximum increase shown by a herd was 234 gallons per cow.

Milk record certificates. The number of milk record certificates issued to members was 2,065. This number represents 1·62 per cent. of the total number of cows recorded. Of the 2,065 certificates issued, only 155 were for yields of less than 6,000 lb., 1,367 were for yields between 6,000—10,000 lb., and 543 were for yields of over 10,000 lb.

Register of dairy cattle. The seventh volume of the Ministry's Annual Register of Dairy Cattle,[1] covering the year under review, has been issued. It contains particulars of 1,321 cows (belonging to 271 members) in respect of which certificates have been issued by the Ministry showing that they have certified yields of 8,000 lb. or over of milk during the milk-recording year ended 1st October, 1923, or an average of 6,500 lb. for that year and one or more preceding consecutive years. Twelve recognized breeds or types are represented in the seventh volume, and there are, in addition, 57 cross-bred cows (*i.e.*, cows which do not conform to one recognized breed or type), whose milk yields have justified their inclusion under the standard required. Of the 1,321 cows entered in the seventh volume, 1,165 gave over 8,000 lb. of milk during the year, and 156 were entered on an average of 6,500 lb. or over. Of the 1,165 cows which were entered on one year's yield, 482 gave over 10,000 lb.

The seventh volume of the Register contains the second list of cows in respect of which certificates of merit have been issued certifying that such cows have yielded not less than 24,000 lb. of milk over a period of three consecutive years and have calved at least three times during that period. This section, and the sections for dairy bulls, have been better supported than was the case in the previous volume, and it is hoped that in course of a few years the information given in these sections will constitute a valuable part of the register. Steps are being taken by the Ministry to popularise the register and to increase its scope and usefulness to all classes of dairy farmers.

After consultation with its Advisory Livestock Committee the Ministry has made certain important changes in the conditions of entry into the Register, the principal of which are :—(1) the issue of a Certificate of Milk Record will not be required as a condition of entry ; (2) entry will be made on the basis of one year's yield only.

The alterations have been made with the object of securing a more comprehensive and valuable book of reference for the use of members of milk-recording societies and others interested in dairy cattle, and Vol. 8 of the Register will contain entries of approximately 5,000 of the highest yielding cows of all breeds and types. A copy will be presented free to each member of a milk-recording society who records under the Ministry's scheme.

Cost of milk-recording. The marked tendency for costs to increase which had been noticed in previous years was checked in the year ended 1st October, 1922, and, as was anticipated, the results for the year under review show a distinct

[1] Price 2*s.* 6*d.*, post free from the Ministry.

reduction in costs, notwithstanding increased activities on the part of societies. About 30 per cent. of the societies have been able to reduce their levies per cow by 6*d.* or more, and, with very few exceptions, societies are in a sound financial condition.

Commercial value of milk-recording. The commercial value of milk-recording continued to be demonstrated by the prices realized at sales for recorded non-pedigree cattle and their progeny, and although, as was anticipated, the exceptional prices realized during the boom period of 1921 were not so evident, it is noteworthy that milk records are much more frequently seen in sale catalogues and asked for in private transactions than was formerly the case.

Advice on rationing. Much greater interest has been evinced in the schemes instituted by the County Agricultural Organizers for the economic feeding of dairy cows and butter fat testing. The very useful advice and assistance given by the Organizers are much appreciated and the adoption of balanced and economical rations should prove of great value—financial and otherwise—to members of milk-recording societies.

Calf marking. The Ministry's Calf and Bull Marking Schemes, the adoption of which is optional, have now been taken up by all but two societies, and interest is steadily growing as members realize the value of officially identifying the progeny of their recorded stock. The number of animals marked under this scheme during the year was, 12,647 as compared with 11,517 during the preceding year.

Statement giving particulars of 55 milk-recording societies operating during the year ended 1st October, 1923.

(The societies are arranged in order of total number of animals recorded.)

Name of society	Number of members	Number of herds	Total number of animals recorded	Number of cows recorded for full year	Average yield of cows recorded for full year
					lb.
Essex	215	238	7,902	4,388	7,499
East Sussex	190	229	6,730	3,595	7,311
Hampshire	176	194	6,166	3,251	7,014
Yeovil and Shepton Mallet	150	171	5,404	3,191	6,749
Berkshire	135	150	5,378	2,788	6,845
Hertfordshire	159	178	5,290	2,681	7,200
Kent	163	186	4,974	2,613	7,200

Statement giving particulars of 55 milk-recording societies operating during the year ended 1st October, 1923—contd.

Name of society	Number of members	Number of herds	Total number of animals recorded	Number of cows recorded for full year	Average yield of cows recorded for full year
					lb.
North West Wilts	106	119	4,714	2,736	6,902
Dorset	77	103	4,568	2,720	6,599
Surrey	170	180	4,360	2,174	6,796
Norfolk	144	165	4,253	2,392	7,601
West Sussex	109	119	3,738	1,815	7,255
Oxford	102	109	3,666	1,992	6,950
Salisbury	61	86	3,654	2,338	7,524
Lancashire	131	139	3,574	1,485	6,735
Warwickshire	121	131	3,137	1,604	7,070
Leicester	100	103	2,718	1,447	7,414
Suffolk	107	116	2,513	1,642	7,365
South Devon	97	106	2,452	1,198	6,309
Northants	91	103	2,320	1,271	6,668
Yorkshire	140	141	2,317	1,018	7,333
Shropshire	70	78	2,163	1,383	7,309
Cambridgeshire	83	91	2,150	1,239	7,415
Cheshire	58	64	2,141	1,031	7,152
Cumberland	141	143	2,026	891	6,089
Stafford	71	75	1,837	982	7,519
Nottingham	53	55	1,764	888	6,821
Buckingham	66	71	1,709	835	8,239
Derby	48	51	1,685	809	7,329
Bristol and Bath	76	77	1,537	831	7,281
Denbigh and Flints	70	72	1,459	961	6,685

Statement giving particulars of 55 milk-recording societies operating during the year ended 1st October 1923—concld.

Name of society	Number of members	Number of herds	Total number of animals recorded	Number of cows recorded for full year	Average yield of cows recorded for full year
					lb.
Worcestershire	62	65	1,416	748	6,948
Peak	57	57	1,266	480	7,004
Warminster and Mere	27	31	1,191	877	6,849
Cadbury	37	45	1,152	761	6,741
Tees Valley	30	37	1,080	438	7,334
East Devon	64	64	1,016	467	6,716
Bedfordshire	36	37	945	510	7,436
Kendal and South Westmorland	47	47	856	386	5,841
Frome	20	20	853	567	6,431
Cornwall	50	50	777	446	6,020
North Somerset	31	35	764	473	6,898
Lincolnshire	33	36	755	361	7,175
Anglesey and Carnarvon	60	62	753	432	5,454
Allendale	40	41	741	433	7,034
United Counties	47	48	732	421	6,544
Monmouth	34	36	627	327	6,511
Herefordshire	27	27	620	329	7,026
Campden, Morcton and District	33	33	575	366	6,940
Gloucester and District	32	34	563	295	6,848
Melton Mowbray	26	26	556	295	6,682
Cotswold	25	25	523	359	7,474
Montgomery	23	23	421	223	6,031
Highbridge	15	16	382	226	7,048
Glamorgan	29	29	288	Commenced 1st April 1923.	
TOTAL	4,365	4,767	127,151	68,349	7,042

Sheep. Since 1919 the Ministry has given some financial assistance towards the improvement of Welsh Mountain Sheep. Grants up to a maximum of £10 for each ram provided, at the rate of 3*s.* 4*d.* per ewe served, were made to 14 societies in respect of 17 approved pedigree rams, during the year ended 31st March, 1924. The average hiring fee of the rams was £9 13*s.* and the average service fee 1*s.* 5*d.* The number of ewes served was 1,020, an average of 60 per ram.

The scheme, which is in its infancy, promises well, and one excellent result of its operation has been that several members of societies have purchased pedigree rams of their own.

Heavy horses. It was possible to revive the grants to Heavy Horse Societies, which were discontinued after 1921, owing to the urgent demand of economy at that time. As the announcement that grants would be available was only made in February last, full advantage could not be taken of the scheme for the service season of 1924. It is confidently anticipated, however, that next year it will be possible to continue the good work accomplished by the scheme during the years 1914—21.

The following are the principal memoranda used in connection with the livestock operations of the Ministry, and copies of them can be had free of charge on application to the Secretary, Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W. 1 :—

Leaflet 282.—Scheme for Improvement of Livestock.
Leaflet 146.—The Value of Records of the Milk Yields of Cows.
No. 609-T. L.—Bull Grant Regulations.
No. 392-T. L.—Milk-recording Regulations.
No. 466-T. L.—Boar Grant Regulations.
No. 86-T. L.—Heavy Horse Regulations.

Light horse breeding. The administration of the Light Horse Breeding Scheme was transferred to the War Office on 1st April, 1924, and the following report on the year 1923-24 marks, therefore, the termination of the Ministry's active interest in the scheme which was inaugurated in 1910, and has thus been in existence for 14 years. The operations of the scheme during that period have been described in the annual reports published by the Ministry.

During the year 1st April, 1923—31st March, 1924, the scheme was carried on by the Ministry on the usual lines. It was satisfactory that sufficient stallions of the requisite merit were forthcoming at the Thoroughbred Show in 1923 to enable the full number of King's and Super Premiums to be awarded, which was not the case in the preceding year.

Premiums awarded for 1923 season. The following premiums were awarded for the season 1923 :—12 Super Premiums, 48 King's Premiums and 15 Ministry's Premiums (all thoroughbred horses except 3 Ministry's Premiums which were awarded to 1 Hunter stallion and 2 Cleveland Bay stallions), 5 Riding Ponies, 18 Welsh Cobs,

3 Welsh Roadsters, 4 Dales Ponies, 5 Fell Ponies, 15 New Forest Ponies and 40 to Mountain Pony Stallions in Wales.

Service season, 1923. The service season of 1923 showed considerable improvement on that of 1922, the average number of mares served by both the King's and Ministry's premium stallions showing a marked increase. The numbers of mares served by the various classes of stallions were as follows :—

—	No. of mares served	Average per stallion
12 Super Premiums	966	81
48 King's Premiums	3,437	72
15 Ministry's Premiums	886	59
5 Riding Pony Premiums	208	42

Foaling results from service season, 1922. The foaling results from the 1922 service season showed a slight improvement on the previous year. The foaling percentage of stallions is calculated upon returns furnished to the Ministry by the mare owners, and the results from the 1922 service season were as follows :—

—	Number of mares served in 1922	Number of returns furnished to Ministry	Average percentage of foals
12 Super Premiums	855	841	56
45 King's Premiums	3,033	2,952	53
15 Ministry's Premiums	872	845	54
5 Riding Pony Premiums	205	201	63

The highest percentage (73) was obtained by "Ballyvodock," now owned by Mr. Terry O'Brien, Ballyvodock, Midleton, Co. Cork.

Thoroughbred show, 1924. At the request of the War Office the Ministry made the usual arrangements in conjunction with the Hunter's Improvement Society for the Annual Show of Thoroughbred Stallions for the purpose of awarding premiums to stallions for the service season 1924. The show was held at the Royal Agricultural Hall on 4th, 5th and 6th March, and the Judges were Mr. Ernest Bellaney and the Hon'ble Alexander Parker. The number of entries was 94, seven more than in 1923, and of these, 30 were stallions which had not previously been shown. The full number (60) of Premiums (including 12 Super Premiums) was awarded and the King's Cup was won by "Scarlet Rambler" belonging to Captain T. L. Wickham Boynton and Henry A. Cholmondeley, the Reserve horse being "Gay Lally" belonging to the Compton Stud, thus reversing the positions occupied by these two stallions during the previous three years.

Horse Breeding Act, 1918. During the licensing year 1st November, 1922, to 31st October, 1923, there was again a marked decrease in the number of stallions licensed under this Act, the number being 2,761 as compared with 3,479 in the preceding year. The proportion of stallions for which licenses were refused remained almost the same. There were 136 refusals, 15 of which were after appeal, the numbers for the previous year being 165 and 16 respectively.

Of the 2,761 licensed stallions, 2,512 were pedigree animals and the remaining 249 were horses that were not entered or accepted for entry in any recognized stud-book.

The following tables show the number of stallions of each breed concerned that were licensed or rejected, and the number of refused licences in respect of the various prescribed diseases or defects :—

Number of stallions licensed or refused.

	Pedigree		Non-Pedigree *	
	Licensed	Refused	Licensed	Refused
Heavy				
Shire	1,568	88	66	3
Clydesdale	185	13	6	1
Suffolk	186	5	1	1
Percheron	47	1	..	..
Others	..	..	61	2
Light				
Hackney	179	8	30	..
Thoroughbred	140	6	3	..
Arab	22	2	4	..
Hunter	6	..	5	..
Cleveland Bay	7	..	..	..
Yorkshire Coach	2	..	1	..
Welsh Roadster	3	1	1	..
American Trotter	1	..	7	..
Others	..	..	12	..
Ponies (including Welsh Cobs)	166	2	52	3
Total	2,512	126	249	10

* Non-pedigree stallions are arranged as far as possible under types.

Number of stallions rejected for the prescribed diseases and defects.

Roaring	29
Whistling	41
Sidebone	21
Cataract	12
Ringbone	8
Bone Spavin	10
Defective Genital Organs	2
Stringhalt	4
Shivering	7
Navicular Disease	1
General Unsuitability	1
TOTAL	136

Twenty-three appeals were made against refusals of licences, and in 8 cases these were successful.

Notwithstanding the decrease in the number of stallions licensed, the Ministry has information which suggests that the number of unsound stallions which formerly travelled at very low fees, and which constituted the most serious hindrance to the grading up of horse breeding, have been practically eliminated from the road. Since the Horse Breeding Act came into force the Ministry's inspectors and livestock officers and the police have endeavoured to secure observance of the Act by stopping stallions on the road and requiring the production of the licenses, and in cases where the regulations have been infringed proceedings have been taken by the police. The fact that the number of prosecutions is steadily declining is evidence of a more general knowledge of and compliance with the Act on the part of stallion owners.

TECHNICAL CONTROL IN AGRICULTURE.*

BY

H. M. LEAKE, M.A., Sc.D. (Cantab.), F.L.S.

Let me draw a contrast. I well remember a conversation some twenty-five years or more ago when the advantage of the employment of a works chemist in a cement works was under discussion. The owner was opposed to the suggestion and his argument was, briefly, as follows : by the time the chemist had completed his analysis of the clay and chalk which went to the composition of the cement, these two had been mixed and appeared as the final product. That was, as I have said, some twenty-five to thirty years ago and expressed the then too common attitude of the producer to technical control. I now turn to the other picture. A short time ago a well-known planter was visiting the Imperial College. In the course of discussion the question of the employment of technical control on sugar estates arose and he expressed himself somewhat on these lines ; I give my chemist good pay, free hours, electric light and all I can towards his comfort and he is still the cheapest man in my employ. That expresses the practical view held at the present time by the vast majority of producers employing technical processes and the contrast is very marked. But even in the latter case it is doubtful whether in the balance-sheet full credit is given to the value of the body of workers of whom, in the above cases, the technical chemist is the representative. In the last twenty-five years great changes have come over the cement industry ; the open vats and simple kiln have been replaced by the rotary kiln, and these changes are the joint work of the research chemist and the engineer. In the case of sugar, the substitution of the muscovado process with its open pan by the central factory with its triple effect is the result of the skill of the engineer and of chemical research on the constituents of the juice and on the inversion changes which take place during boiling. On the cultivation side again, the technical chemist financially justifies his existence by control of the manure supplies but in the balance-sheet no credit is given to those large numbers of workers by whose study the principles and the systems of manuring have been worked out.

I have, however, digressed for I am not at the moment concerned to justify the research worker. My aim is to draw attention to the change in attitude towards the technical worker in industrial processes and to compare this with agricultural

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* Reprinted from *Tropical Agri.*, I, No. 12.

development in the same direction. For while this change has taken place in the industrial world but little development is to be noticed on the agricultural side. As a body the planter or farmer keeps a simple system of accounts and neglects the systems of costing employed by the manufacturer. The work of Orwin and the Agricultural Costings Committee had no marked influence and few practical farmers accurately cost out the value of any new practice.

This defect affects even more fundamental issues than the industrial processes to which I have made reference, for it refers to office organization and systems of book-keeping, branches of the manufacturing organization the importance of which has long been recognized in the industrial world. And if such defects are found at this stage of agricultural organization it is hardly surprising that the value of technical control in agriculture has generally been missed, for the recognition of values is in such cases very largely a matter of accurate costing.

What then, is the substance of technical control in agriculture? This must depend in large measure on the type of cultivation employed. It will take one form in the case of plantations growing tea, rubber, cocoa and the like which are perennial orchard crops; it will take another form in the case of mixed farming with short season crops as sugar, cotton, oilseed and so on. It will take one form if the land is owned directly and worked by paid labour, it will take another if the land is leased and worked on a tenancy basis. In the former cases it takes the form of actual skill in the practical handling of the land and of the stock and crops which the land carries; in the latter cases this aspect is not so important and technical skill will be re-inforced by a knowledge of the relationship between landlord and tenant, of the organization of credit and co-operation and of the best markets for buying and selling.

The importance of technical control as it applies to the plantation is fairly generally recognized though much remains to be done to introduce into practice the results of recent research. When, however, we turn to the question of estate management and tenancy, technical control is mainly conspicuous by its absence, One of the main difficulties of small holdings, whether held directly or under lease, lies in the provision of capital. With a correct relationship between landlord and tenant the latter should look to the former to supply his needs in this respect. The subject of the relationship between these two is one that still offers a large field for investigation but, though the main principles are known, they are rarely adopted in practice.

Before such control can be exercised, it is necessary to train men in the principles. Tropical development will be based largely on a tenancy system and the rapid progress now being made in the opening up of tropical areas demands men and trained men, if the correct relationship between the foreign agent of development and the indigenous tiller of the soil is to be established. Even established estates working on a tenancy basis will derive benefit from control of this nature. It is in this matter that the Imperial College can do good work. By working an

estate with a system of tenancy and by a study of this relationship, both practical and theoretical, instruction will be rendered available for the training of the body of men now needed. Just as the recognition of the need of technical control in industry was slow in coming, so the recognition of this need, as I have defined it, for agriculture, may be slow to develop, but I look forward to a time when the owners of estates will be making of such managers the same observations as were recently made of the chemist by the planter to whom I have made reference above.

THE BRITISH EMPIRE AS A PRODUCER OF THE FLAX AND HEMP GROUP OF FIBRES.*

BY

ALFRED WIGGLESWORTH.

The full possibilities of the British Empire as a fibre producer have never been adequately explored. Within its boundaries, every climate from Arctic to Equatorial is found, and the varied conditions of soil and altitude permit the production of every class of fibre required for our diversified manufactures. The three essentials for successful fibre production are (1) suitable soil, (2) adequate rainfall, (3) abundant and cheap labour supply. If any one of these conditions be lacking, one cannot look for a development of the industry.

Jute. *Corchorus capsularis*, or *Corchorus olitorius*, is a product confined exclusively to Bengal. Before 1838 this fibre was unknown to commerce, but to-day the crop totals a million and a half to two million tons, of which the United Kingdom consumes approximately one-sixth, while Calcutta requires for its fifty mills some nine hundred thousand tons, or 60 per cent. of the entire crop.

Hemp. Besides jute, India has a fairly large production of a variety of hemp fibre, commercially known as "sunn hemp," botanically as *Crotalaria juncea*. The plant is wide in its distribution, being found all over the country, and the methods of preparation differ as widely. Occasionally it is sown to be ploughed up after the rains, as a fertilizer, as its roots are known to occlude nitrogen. In Bengal it is sown in autumn as a cold-weather crop, and is harvested and prepared in springtime into one of the best varieties of fibre, of good colour and fair tensile strength. In the Benares and Allahabad Districts it is sown in springtime, and has to contend with the heat of summer and retting in water above the normal temperature, resulting in fibre too weak to permit of perfect cleaning, so that it ranks amongst the lowest types of the hemp class and can only be used for the manufacture of heavy twines. Jubbalpore and the adjoining districts Itarsi and Seoni produce a strong greenish type of fibre which can be used as a substitute for Russian. The output of hemp in India varies considerably, but exports average about 20,000 tons annually.

Coir. The Malabar Coast and Ceylon supply the world with the bulk of requirements in coir fibre and coir yarn, prepared and spun locally by native labour. The industry is soundly established on progressive lines, and the cleverness of the work-

* Reprinted from *The Textile Manufacturer*, July 15th, 1924.

people permits the manufacture of articles which find a wide use. Again the abundant supply of cheap labour is the factor which makes India paramount in this trade, and it may be doubted whether the Pacific Islands and Africa are likely to emulate India to any great extent in this utilization of the waste products from the coconut.

Ramie. Ramie, or rhea (*Boehmeria nivea*), has long been a subject of research. The plant grows widely in India, Africa and in other tropical and semi-tropical regions, but the absence of a really effective machine for its preparation has prevented its development, although fortunes have been spent in experimental work. The problem is surely not insoluble. At present the world depends for its exiguous supply from China, where the fibre is laboriously stripped stalk by stalk, with the aid of a very primitive apparatus, by nimble fingers.

Pita Fibre, or *Pita floja.* In the Magdalene River district of Colombia (South America) there are vast areas of this plant growing under forests or in the open, which contains a fibre which is finer and longer than manila or sisal. Experiments are now being made with various types of machinery suitable for handling this fragile leaf. If successful, a useful fibre may become available for twine and cordage purposes. Rubber planters in Malaya are keen to find a secondary crop, so as not to depend too exclusively on one article. They have an eye on Pita as a possible fibre producer, provided a suitable machine be found for its preparation.

Sisal. Agave sisalana is an article which, although of very recent interest to the British Colonies, gives promise of healthy and rapid development in those areas which have proved suitable for its cultivation. The cultivation of sisal on a large scale in Africa is of very recent origin. The Germans began by planting experimentally in 1893. A few years later they sent the first small consignment of sisal fibre to Hamburg, which was found to be of excellent quality. By 1913 they had increased the output in their East African territory to 20,000 tons per annum. Meanwhile Kenya began in 1907 experimental plantations in the highland district of Thika, at some 6,000 feet above sea-level. At the present time the production in Kenya is 8,000 tons per annum, with the prospects of rising to 12,000 tons within the next year or two.

The conditions in Mexico, the original home of the plant, are less favourable, both as regards labour and growth, than those of Africa, so that there is some justification for the hope that these British Colonies will in course of time be able to supply the whole requirements of the Empire, with a considerable surplus for export to other European countries and to America. Already the United States take a substantial quantity as they are able to manufacture from this superior fibre a better quality of binder twine than that which is obtainable from the Mexican henequen.

Java. The Dutch have developed in recent years a very substantial production of sisal of a very high quality. The pivotal organization is a very large company which has undertaken production on a vast scale. They have made a special study of the washing of the fibre so as to produce material of the very best description. The results have certainly satisfied consumers and from a few thousand tons the

production has now grown until it is in the neighbourhood of 25,000 tons per annum.

New Zealand. The New Zealand hemp industry dates from the introduction of machinery for stripping and cleaning for export. The fibre had long been known to the Maoris who produced from it not only cordage and fishing twines, but also garments so fine in texture that the British settlers believed they were made from flax. Attempts to prepare the fibre mechanically to the high degree of perfection obtained by the Maoris by hand labour did not succeed, so that the comparatively coarse fibre prepared from this plant, *Phormium tenax*, is devoted exclusively to cordage and twine purposes.

Mauritius. This small island has long been famous for a type of fibre which has not been produced to quite the same perfection in any other quarter of the globe. From the leaves of the *Fourcroya gigantea* the islanders extracted a fibre from four to six feet long, softer and finer in texture than sisal or New Zealand, white in colour, and well adapted for the production of certain fancy articles in the cordage and twine trades. An attempt was made before the war to introduce machinery, a Krupp decorticator having been imported by the Agricultural Department, but it did not succeed in stimulating the production. The high price of sugar, combined with the low value of fibre, has during the last ten years discouraged the production of Mauritius hemp ; but the demand is again reviving, and it may be anticipated that the industry will continue on the same old-fashioned lines of small production and the cleaning of material by hand.

Manila Hemp. Manila hemp is the fibre most adapted for the manufacture of ropes for marine purposes, as it resists the corrosive influences of sea-water better than any other fibre. At present its production is confined exclusively to the Philippine Islands, and the crop is steadily increasing, as will be seen from the following table :—

TONS AND VALUE OF MANILA HEMP EXPORTED.

	1921	1922	1923
United States	36,487	83,283	87,610
United Kingdom	45,968	61,213	70,231
Elsewhere	36,644	40,076	48,410
	119,109	184,572	206,251
Value on the basis of " J " grade .	£4,883,469	£6,090,876	£6,806,283

No part of the British Empire has so far succeeded in producing this fibre, although experiments have been made in various districts whose climatic conditions approximate those of the Philippines.

Cannabis sativa. We now come to the true hemp, *Cannabis sativa*, the oldest textile fibre. In years gone by England grew hemp in Dorset, Somerset, and Lincoln,

where it was locally spun and twisted into ropes and twines, thus constituting the nucleus of many important branches of business, some of which still flourish, Bridport is still an important centre, especially for fishing twines ; but it no longer secures supplies from local sources, these having been supplanted last century, first by Russian hemps, and later supplemented by the Italian variety of the same plant. These two classes of fibre produce the highest grades of polished twine and ropes for marine purposes.

There is no record of any serious effort within the British Empire to produce hemps to take the place of Russian and Italian varieties. In Russia the system of preparing the material by growing it in small patches, and cleaning and preparing it by the hand labour of the grower and his family, is analogous to the system in vogue in India for the preparation of jute. No machinery whatever is used, yet before the war about 124,000 tons per annum were grown on two million acres, of which 64,000 tons were exported and 10,000 to 15,000 came to England. The Russian variety is especially strong, of a light-green colour, and it averages in length four to six feet. Since the war this trade has been dislocated, but is slowly reviving.

The cultivation of hemp in Italy is conducted on highly scientific lines, especially in Northern Italy, where farmers employ the very latest agricultural machinery and utilize the scientific information they receive from the agricultural committees, who issue reports on the nature of the soil and the class of fertilizer best adapted to each particular district. Further, they take germination tests of seed, and generally supervise the cultivation. They provide machinery on co-operative principles, both to cultivate the crops and to prepare the fibre for market. The scutching machinery is sent from farm to farm, thus relieving small growers of the expense of the purchase and upkeep of fairly complicated and expensive machinery. Italian hemp attains a height of ten or even twelve feet. The ideal conditions of climate during the growing and retting season facilitate the production of pure lustrous fibre of a light colour and of high tensile strength.

Flax (*Linum usitatissimum*). The war brought us perilously near a cessation of supplies of flax essential during the war, and no less essential for ordinary daily consumption in peace time. Various committees were appointed during the years 1915 to 1918 to report on substitutes for flax, and to investigate the possibility of its production within the Empire. Lord Colwyn's Committee reported that there were no real substitutes for flax. Encouraged by the steady increase in price during the war, the experimental cultivation of flax was extended to various parts of the Empire. Ireland, which is the only country within the Empire which has retained the cultivation of flax on a commercial scale, increased its area from 59,305 acres in 1913 to 143,385 in 1918 ; but this still left a lamentable shortage, seeing that Russia had normally supplied some 80,000 tons per year, or approximately 85 per cent. to 90 per cent. of the total consumption in the United Kingdom. Unfortunately the area has since 1918 been seriously reduced as the result of low prices and poor demand.

In 1913 I was instrumental in starting flax cultivation in East Africa. It had been ascertained that, in the highland area of Kenya some 7,000 feet to 8,000 feet above sea-level, a quality of flax could be produced which compared favourably with the medium grades of Belgian, and which was on the whole decidedly superior to the average quality obtainable from Russia. The cultivation was readily extended until the year 1920, when the area was increased to 27,174 acres, and it really looked as though Kenya might become an important source of supply of flax. Unfortunately for the industry and for the Empire, the serious depression which set in brought down prices from about £400 to £70 per ton, resulting in an entire dislocation of this budding industry and the closing-down of a large number of plants which had been erected in this new colony on the most improved lines and with the very latest machinery.

While Kenya was developing flax cultivation, in Canada, where for many years past a nucleus of flax production had been preserved in Ontario, the banks and other financial institutes were liberally financing the production of flax on an increased scale. The results, as far as quality is concerned, were satisfactory; but the drawback in Canada is unquestionably the high rate of wages, which raises the cost of production to a point which can scarcely hope to compete with the Russian and African product.

Australia stands in the same position. Good flax was grown there during the war, and was eagerly absorbed by local manufacturers, who found themselves at a loss to obtain any of the supplies from Europe, which were jealously guarded by the various War Departments. The high wages in Australia, however, stand as a barrier against the production of flax or hemp, as long as existing conditions continue.

NOTES

SULPHATES FOR MONSOON CROPS IN SOUTH BIHAR.

In 1923, a strain of *kalai* (*Phaseolus mungo*) was found to suffer from severe chlorosis. Seeds were collected from diseased plants, and in 1924 an experiment was tried at Sabour to test the effect of certain metallic salts, whether they would be able to improve the condition of the crop and prevent the yellowing. The salts tried included the following applications per acre : Lead carbonate (20 lb.), zinc sulphate (20 lb.), manganese sulphate (100 lb.), magnesium sulphate (200 lb.), lime (200 lb.), gypsum (200 lb.), boric acid (5 lb.), potassium iodide (5 lb.), sodium chloride (20 lb.).

Although the yellowing of the leaves was not controlled in any of the experimental plots, the result was remarkable in showing the effect of the sulphates. In all the plots to which sulphates were applied the growth of the healthy plants was distinctly more vigorous, gypsum giving the most favourable result. Even the small application of zinc sulphate at a rate equivalent to 4 lb. of sulphur seemed to produce a striking improvement on the growth. Whether this was wholly due to the sulphur or partly due to the presence of the basic ion will be tested by further experiments on the effect of zinc sulphate as against sulphur and some other zinc salt on healthy plants. No difference, however, was perceived between plots which were unmanured and which were treated with other salts than sulphates.

This experiment indicates that application of sulphates, and particularly of gypsum, will probably be found useful in South Bihar. Sulphur is one of the essential elements of plant life. The requirements of the plant in respect of this element were, however, believed to be so small that the soil was always supposed to be plentifully endowed with it. In fact where the application of a sulphate like gypsum produced any good effect the result was believed to be not so much due to sulphur as to the physical improvements in the soil caused by it and to an interaction between the base (lime) and the insoluble bases in the soil resulting in the production of soluble plant foods. The Bihar soils in many places contain practically no sulphates and at most places less than 0·001 per cent. In recent years attention in this province has been drawn to the improvement in the crop production by the application of sulphur or sulphates and one of the tangible results achieved has been the effect of the application of sulphur and gypsum on the sulphate-starved soils of Chota

Nagpur[1] and South Bihar. The practice of applying sodium sulphate (*khari nimak*) to paddy to improve its condition has long been known. The experiments made by the Howards at Pusa show that the effect of the application of sulphuric acid and sulphur was distinctly better on cotton and indigo[2] than that of superphosphate, so that the increased production due to the latter is presumably not wholly due to the phosphate in it and a considerable part is probably played by the calcium sulphate it contains. Further tests of varying quantities of sulphur on a variety of leguminous monsoon crops will be taken up. [M. N. Ghosh and S. K. Basu.]

SHORT-PLANTING OF SUGARCANE.

This term is applied to the procedure adopted when the rapid multiplication of a selected cane is the object in view. It is calculated that by the use of this method it has been possible to get selected canes out to the growers in bulk in the fourth year instead of after six or seven years in the usual course. This saving of time is of the utmost importance, as not only does it enable an improved cane to be quickly taken up but it also allows any cane which may suddenly develop unsuitable characters to be replaced over a large area in a short time. The idea originally struck the writer when observing the method adopted in the Java hill nurseries for securing the maximum amount of seed. In Java, with constant irrigation and a cane growing throughout the season, the operation is comparatively easy. In North Bihar it has several difficulties to contend with. Firstly, it is absolutely essential that the cane should be grown under irrigation and forced along during the hot weather. Secondly, to secure optimum results the monsoon must break early as the cane must have three weeks' monsoon conditions before it is cut. If cut immediately at break, nothing like the same amount of material will be obtained. Lastly, it has got to be planted out on high land, very shallow, and done well. With all these conditions favourable it will be found that seed from one acre will plant 6 in August and this six acres cut in February will afford planting material for 36 acres which in August following will plant out 216 acres and so on. This enables any large grower to obtain a seed nucleus for estate planting in one year. It is also extremely useful in filling up the gaps in the main crop, as all places near the edge of the crop which have failed or gone out in the hot weather can be planted from material cut from the strongest part of the crop in August. This planting will give excellent seed material the following February.

Seed from short-planted cane is invariably excellent and the amount of rejections comparatively very small. Experiments have shown that its germination is earlier

[1] *Agri. Jour. Ind.*, XV, 1916, pp. 310-311.
[2] *Agri. Jour. Ind.*, XVIII, 1923, pp. 148-153.

and growth stronger. The ideal method of obtaining seed for a large estate would be to maintain an area of short-planted cane to draw from and thereby separate cane grown for sugar from cane grown for seed, as the riper a cane is the less suitable it is for seed.

The operations when short-planting are simple. The first lot of cane when cut after the break of monsoon should be cut completely down, all top which does not show colour should be cut off. There is no need for the eyes to be swollen. They may be practically invisible and yet will germinate perfectly, provided the cane is formed and shows colour. There is no need to plant the sets eye to eye as the internodes will be comparatively short. It is most important to plant shallow and manure well. Previous cultivation should be good but can be the minimum as there is no lack of moisture, and if the cane is well manured at planting it does not matter what crop stood on the land previously, provided the land is fairly clean, so that the cane will get a start over the weeds. It is essential that short-planting in the rains should be done in Bihar by the end of July or the beginning of August at the latest. Cane planted later on does not come on so well with the result that the required planting material is not forthcoming. [WYNNE SAYER.]

A NEW VIEW OF SOIL FERTILITY.

PROF. W. F. GERICKE of the University of California certainly seems to have developed a refreshingly novel point of view in relation to the problem of soil fertility, to judge from a preliminary note published in *Science* for 4th April, 1924, which has just been brought to our notice. Pointing out that the rapid growth of a crop often produces a temporary depletion of some essential soil constituent, he investigated by the water culture method the effect upon the growth of a plant of a period in which the salt supply provided lacked one essential element. The striking result was obtained that after plants had grown for one month in complete nutrient solution, a great enhancement of growth, increase in weight, and advance in date of maturity resulted from the transfer to solutions *devoid of potassium*. In the light of these experiments Prof. Gericke attempts a reinterpretation of the results obtained by Stewart (*Journ. Agri. Res.*, 12, 311-368, 1918), in which it was shown the barley crop very rapidly depleted the soil of nitrogen in the cases where large crops were obtained. From other water culture experiments Gericke had reached the conclusion that the presence of the nitrate ion materially affected the availability of the potassium ion to the plant, and he, therefore, inclines to associate these large yields in soils early depleted of nitrate with these new experiments in which lack of available potassium after the first few weeks of growth favours increased growth and yield. Needless to say, potassium, and indeed the full supply of nutrients, proves to be essential during the first few weeks of the plant's growth. Prof.

Gericke reports similar improved development and yield in plants transferred, after four weeks in full mineral solution, to media devoid of phosphorus. [*Nature*, No. 2870.]

THE CO-OPERATIVE MOVEMENT IN DANISH AGRICULTURE.

THE following notes on the co-operative movement in Denmark, taken from the Annual Report by the Commercial Secretary at the British Legation, Copenhagen, may be found of interest :—

The first supply association was founded in a Danish town in 1866, and was based on the supply of goods to the working population at market prices, and the distribution of profits in proportion to the value of the goods purchased. In the course of time the movement spread and there are now some 2,000 supply associations throughout the country, both in the towns and in the rural districts, with a membership of about 350,000.

In connection with these supply associations, a " Joint Association of Denmark's Supply Associations " was founded in 1896, for the purpose of making the wholesale purchases for the various supply associations. In the course of time this central association founded a number of industrial undertakings (tobacco, chocolate, soap, margarine, bicycles, rope, knitted goods, leather and footwear, certain kinds of iron goods, and chemical technical articles) for the supply of the goods required, the turnover of these factories amounting in 1921 to Kr. 35,000,000, while in the same year the turnover of the joint association totalled some 175,000,000 kroners.

In 1898 was founded a Co-operative Fodderstuff Purchasing Association, and now between 35 and 40 per cent. of the country's imports of fodderstuffs (oilcake, maize and particularly in 1923, barley) are handled by such associations. Similarly, the Danish Co-operative Fertilizer Association (founded in 1901) supplies fertilizers to some 1,600 local societies throughout the country, with a membership of about 80,000 farmers. The central institution purchases and distributes to the member societies, on the basis of mutual guarantee, the extent of which is dependent on the size of the agricultural district in question.

Other articles required by the agricultural community are handled on co-operative lines, of which mention may be made of fuel and seeds.

The application of the co-operative principle to agriculture is, in Denmark, most characteristically shown in producing associations—co-operative dairies, " slaughteries " and egg collecting associations.

The Danish Co-operative Dairy Association was founded in the eighties with the object of extending to the smaller farmers the advantages to be gained from the production of milk in bulk, by improving the level and quality. The method employed is for a number of farmers in a district to combine to erect a dairy, the capital for the construction being advanced by a local bank on the basis of the absolute

liability of the interested parties. In this manner, upwards of 14,000 co-operative dairies have been erected in the country which to-day handle nearly 80 per cent. of the milk output, amounting to some 3,500,000 tons per annum. The farmers, who are bound to deliver all their milk to the dairy of which they are members, are paid by the dairies on what amounts in practice to the actual butter fat contents of the milk delivered. The dairies pay all overhead charges, such as transport, so that in this respect all the members of a dairy are equally placed, whether their farm lies far from or near to the dairy. Of the butter produced in these dairies, some 30 per cent. is moreover sold by the Butter Export Association, the remainder being handled by private farms.

The 46 co-operative "slaughteries," founded on similar lines, now handle about 90 per cent. of the total bacon production of the country. The output is mainly sold through British firms, but one co-operative selling association exists comprising nine "slaughteries." The co-operative "slaughteries" also interest themselves in the improvement of the stock by the establishment of stud farms and the publication of pedigrees, etc.

As regards eggs, the Danish Joint Egg Export Company has a membership of about 500 egg associations throughout the country with some 50,000 members. These members are bound to deliver eggs stamped so that they can be traced back in case of complaint.

Further, a Joint Cattle Export Association exists embracing a number of local associations throughout the country, the members undertaking that their sale of cattle, outside their own district, shall be made through the association. The cattle in question are delivered to the society on a fixed day in the week, and the farmer receives the estimated value, less a small working commission to the association. The cattle are then sold by the association, at the best terms obtainable, and at the annual balancing of the books, the profits or losses are divided among the members in proportion to the number of beasts delivered throughout the year. (*Mutatis mutandis* a similar procedure is followed by the other co-operative selling associations, the seller receiving an amount based on periodical quotations at the time of delivery, and a share of the year's profits *pro rata* of his deliveries.)

The co-operative system is also applied in many other directions; indeed, there is practically no aspect of agricultural life in which, in some degree or other, co-operation has not been called upon to play a part. A cement and a machinery factory, electric power stations, various forms of insurance and finally a joint stock bank, with branches throughout the country, may be mentioned. In 1921 this bank had a turnover of Kr. 11,500,000, while the annual turnover of the various co-operative concerns (apart from the bank and the power stations) is estimated at about Kr. 1,500,000,000.

The question of the establishment of a shipping concern by the co-operative producing associations has recently been revived, but no definite decision has as yet been reached in the matter.

BANANA PRODUCTION IN THE EMPIRE.

We have received the following for publication :—

Although many people in the United Kingdom associate the banana particularly with Jamaica and the Canary Islands, not more than two-fifths of the fruit imported into the country comes from those countries, the remaining three-fifths being supplied by Colombia, Costa Rica and the Republic of Honduras.

In 1922, bananas were imported into the United Kingdom to the value of over £5,300,000, of which amount only about £600,000 represented produce of British Possessions. In view of the fact that the banana can be grown in most tropical lands where labour is available, it would therefore seem advisable to consider whether a greater share in the banana industry could not be undertaken within the Empire, more particularly in parts of West Africa which are within a comparatively short distance of the home market. The present position of the industry in the various countries of the Empire is indicated in an article on "The Banana and its Cultivation with special Reference to the Empire," published in the current issue of the *Bulletin of the Imperial Institute*, which also gives particulars of methods of growing the fruit and the preparation of various products, such as banana flour and dried bananas or "figs." Of the British West India Islands, Jamaica is the only important banana producing country, and last year exported (largely to the United States) 12½ million bunches, valued at over £2,250,000, whilst in some years the exports have exceeded 16 million bunches. Trinidad, Barbados and Dominica formerly exported small quantities of fruit but the trade has now almost ceased. British Honduras has an annual output of about half a million bunches, but British Guiana, although producing fruit of excellent flavour, has so far not built up an export trade. In Australia, considerable quantities are grown for local consumption in Queensland and New South Wales, and there is also a large import from Fiji, where banana growing is one of the staple industries. Other parts of the Empire, such as India, Ceylon, Malaya, and East and West Africa, at present only grow the fruit for their own use.

COTTON NOTES.

Through the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

Cotton Cultivation.

A copy of a questionnaire was sent to various cotton growing countries, except the U. S. A. and Egypt, by the International Federation of Master Cotton Spinners' and Manufacturers' Associations. The questions are as to acreage, types grown,

times of sowing and picking, yields, labour, costs, transport, pests, ginning and baling, etc. Replies from 31 areas are given in subsequent pages (*see* following abstracts). [*Int. Cotton Bull.*, 1924, **2,** No. 8, 425-426.]

Cotton Cultivation in Belgian Congo.

Replies to the above questionnaire show that cotton is only grown by natives. The 1923 crop was grown on about 20,000 acres yielding an estimated crop of 1,200 tons, *i.e.*, averaging about 130 lb. per acre. (The average size of a native field is about one-seventh of an acre.) For future expansion the area is unlimited but only in the northern districts (Welle) is the labour supply sufficient. Cotton has to be carried on the average a four days march by the natives, followed by 500 miles of inland transport, before leaving the country. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 496-497.]

Cotton Cultivation in China.

Replies to the above questionnaire show that five and a half million acres of cotton are grown in China and a further three-quarters of a million might be added in the next four or five years, if there were strong organizations to lead in extending cotton growing. Expansion is possible only in the northern provinces of Chihli, Honan, Shantung and parts of N. Kiangsu. One-eighth of the total crop in 1922 was American Upland and the remainder the Chinese Annual type. On the average about 200 lb. per acre are produced at a cost of 5·15*d.* a lb. Progress is dependent on demilitarisation within the Empire and on the provision of the necessary funds for research and cotton growing experiment. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 487-489. T. S. Kuo.]

Cotton Cultivation in Italian Somaliland.

Replies to the above questionnaire describe the efforts which are being made by the Societa Agricola Italo-Somala ("Sais") to introduce cotton growing. Last year 263 hectares were planted, yielding about 370 lb. of lint per acre; the staple was 32-38 mm. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 512-514. Societa Agricola Italo-Somala.]

Cotton Cultivation in Paraguay.

Replies to the above questionnaire show that the area under cotton add the yield have expanded enormously since 1920. This year, 13,000 acres are sown and the yield is estimated at 16 million kilos. More than 300,000 sq. km. situated in the eastern and western sections are suitable for cotton growing. Under presedt conditions of population it is expected 65,000 bales of lint per annum may be produced in a few years. Of the actual production, 98 per cent. is of a uniform type selected from Georgia varieties. The average production is from 300 lb. to 500 lb. per acre

of raw cotton that is generally classed as superior to American, and most of the crop goes to Germany and to Spain. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 509-512. GUILLERMO T. BERTONI.]

COTTON CULTIVATION IN SPAIN.

Replies to the above questionnaire show that only about 9,000 acres are under cotton but $5\frac{1}{4}$ million acres are possibly suitable. The cotton is all of the American type, of which the variety known as Texas reaches 28 mm. in length. No cotton is exported. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 515-516. FRANCISCO DE P. GONZALEZ PALOU.]

COTTON CULTIVATION IN ARGENTINA.

The acreage under cotton has increased from 56,500 in 1922-23 to 154,800 in 1923-24. The Chaco District has 123,550 sown and Corrientes 21,370. Though most of the crop is sold to Germany, Argentine cotton is beginning to find a market in Manchester. [*Int. Cotton Bull.*, 1924, **2,** No. 8, p. 480; 1924, **3,** No. 9, 163-166.]

COTTON CULTIVATION IN ASIA MINOR.

The Adana crop fell from 135,000 bales in 1914 to 14,000 in 1916 and 1917 but the 1924 crop is estimated at 160,000 bales. Under the present biennial system of rotation, cotton cultivation in the future may be expected on between two and two and a half million acres each year, indicating a minimum production of 800,000 bales and a maximum of 2,000,000 bales of 500 lb. In order that this result may be achieved improved methods of cultivation, greater financial facilities to cultivators, reform in taxation and improved communications will be essential. Though the American Upland varieties are far more valuable than the native variety, giving a better yield and having a shorter period of growth, the native cottons have undeniable growing advantages under the existing system of cultivation. The bolls of the native varieties remain fixed to the plant even when they are ripe and do not open completely. Consequently the crop can be gathered in one picking and as labour becomes available, and there is no great risk of damage to the lint from rain and dust storms. The fact that the plant retains its boll until all are ripened also offers greater possibilities for the invention of suitable picking machines. As less heat and water are required for the indigenous cotton, the growing of this crop is also possible at higher altitudes than would be possible with the American Upland type. The only difficulty that stands in the way of a rapid extension of Upland cotton, however, is the picking, for it appears to be well suited to the climate of the country. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 481-486. HUSNI SONS and CHINASSI.]

Cotton Cultivation in Korea (Chosen).

The moderate rainfall in summer and sufficient sunshine and dryness in autumn of the Korean climate allows the cultivation of cotton to succeed at a higher altitude than in U. S. A. Only in S. Korea is it possible to grow the American type of cotton, and King's Improved is the variety grown. Statistics as to acreage sown and yields for Upland and native strains are given. Native cotton is mainly used for wadding clothes, cushions and quilts and spun for home-woven cloth. The fibre is harsh, stiff, very strong and pure white in colour. It is poor in yield and lint percentage and is of small value for power spinning. The Upland cotton suits fairly well for power spinning because the staple is longer and more convoluted and it is superior in yield and lint percentage. Its defects are those of bad colour and "weakness in tension, on account of the infancy in farming and some climatic influence." Data on staple lengths, convolutions, breaking load, etc., are given. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 500-508. S. Kamisaka.]

Cotton Cultivation in S. Africa.

The yield of the 1922-23 crop was approximately 4,800 bales (of 500 lb.). In staple length, 25 per cent. was $1\frac{3}{16}$ in. and over; 43 per cent. was $1\frac{1}{8}$ in.; and 32 per cent., 1 in. and under. In grade, 65 per cent. of the crop was better than Fully Middling, $14\frac{1}{2}$ per cent. was graded Middling and below, while $20\frac{1}{2}$ per cent. was off colour. The available lands for future development, where soil and climate are favourable, comprise generally the whole of the middle and low veld areas; and of those possibly four million acres are suitable for cotton growing. Inefficiency of labour is one of the outstanding problems; but the supply is sufficient, if carefully trained, to build up a production of 500,000 bales in comparatively few years. The cost of production is roughly estimated at £4 per acre and the profit per acre, for an average crop of 600 lb. seed cotton at present prices, is £8. [*Cotton News Weekly*, 1924, **1,** No. 11, 262-264. W. H. Scherffius.]

Effect of density of Cotton Bale on yarn strength.

The effects of baling cotton at different densities, on the strength of the yarn produced, were found to be:—(1) high density compression of cotton, in a dry condition, does not injure its spinning value; (2) the waste of wet cotton compressed to high density is increased, and the breaking strength of the yarn is reduced; (3) round baling with a hard core results in a reduction of the yarn strength about 7 per cent. Pure strains of Cleveland Big Boll, Rowden, Delta and Webber 49 were used in these tests. [*U. S. Dept. Agri. Bull.* No. 1135, May 1923. W. R. Meadows and W. G. Blair.]

Cotton Cultivation in Russia (Turkestan).

The area under cotton in 1923 amounted to about 405,000 acres and, for the current season, efforts were to be made to double the acreage. The 1923 crop yields for Turkestan and neighbouring districts were in bales of 500 lb.:—Turkestan, 190,000 ; Bokhara, 38,000 ; Khiva, 11,000 ; and N. W. Persia, 23,000. This production represented about five-eighths of the raw cotton requirements of the Russian manufacturing industry. [*Int. Cotton Bull.*, 1924, **3,** No. 9, 171-176.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

The designations of—

(1) The Imperial Bacteriological Laboratory, Muktesar,
(2) Director and First Bacteriologist, Muktesar Laboratory,
(3) Second Bacteriologist,
(4) Third Bacteriologist,
(5) Veterinary Officer

are changed to

(1) The Imperial Institute of Veterinary Research, Muktesar,
(2) Director, Imperial Institute of Veterinary Research,
(3) First Veterinary Research Officer,
(4) Second Veterinary Research Officer,
(5) Third Veterinary Research Officer,

respectively.

Dr. W. McRae, Officiating Imperial Mycologist, Pusa, has been granted leave on average pay for six months from 14th April, 1925. Mr. M. Mitra, M.Sc., First Assistant, will hold charge of the current duties of the office of Imperial Mycologist in addition to his own.

The Elliott Prize (Gold Medal and cash) for Scientific Research, for the year 1923, was awarded by the Asiatic Society of Bengal to Mr. Bhailal M. Amin, B.A., Assistant to the Imperial Agricultural Chemist, Pusa.

The title of Khan Bahadur has been conferred upon Mr. Gul Muhammad Abdur Rahaman, Divisional Superintendent of Agriculture, Sind.

Mr. W. Gregson, N.D.A., Deputy Director of Agriculture, has been placed in charge of the Northern Circle, Burma, *vice* Mr. L. Lord proceeding on leave.

REVIEWS

Practical Bacteriology : An Introductory Course for Students of Agriculture.— By A. Cunningham. Pp. viii+188. (London and Edinburgh : Oliver and Boyd.) Price, 7*s.* 6*d.*

This book presents in a highly condensed form a series of laboratory exercises in bacteriological technique for agricultural students. In lecturing on such a subject for examination purposes it is necessary to take into account the lamentable fact that the biology of soils, although fully recognized as of prime importance in connection with the study of the subject of fertility, holds as yet a comparatively unimportant place in agricultural curricula. Hence we find in such a book as this the section (Chapter IV) devoted to bacteriology of soil (and of farmyard manure) occupying some twenty pages out of a total of one hundred and eighty, whereas the previous one (Chapter III) dealing with milk and milk products absorbs thirty-five pages. It is impossible to criticize the author on these grounds ; he has to work to a lecture syllabus for examination purposes and to deal with large classes requiring correspondingly extensive supplies of apparatus and bench and incubator space. Hence it is necessary to restrict laboratory experiments accordingly, and this is most readily done by devoting attention to such lines of work as allow of qualitative rather than quantitative demonstration. The bacteriology of soil, depending as it does upon quantitative measurements rather than upon qualitative investigation, naturally suffers in a lecture course when brought into competition with the more obvious reactions of the dairy bacteriologist, but the responsibility for such neglect rests not upon the lecturer but upon those authorities whose examination policy places the bacteriology of soil in such a subordinate position that funds are not forthcoming for its proper treatment as the most important method of dealing with the fundamental problem of soil fertility. When due recognition is accorded to this subject by our universities it will be possible to arrange for its fuller study even by large classes of students ; such study will then allow of its treatment as a separate subject, complete in itself, and it will no longer be considered necessary to include in lecture courses and text books dealing with it such extraneous studies as those concerned with dairying and the diseases of plants and animals. The author has presented in the present volume a very well written and up-to-date compendium of exercises which should be of great value to lecturers and students ; particularly noticeable is the large amount of useful technical information which has been brought into such a comparatively small compass. [C. M. H.]

Bhuler Fasal (in Bengali).—By D. N. Mitra, District Agricultural Officer, Faridpur. Pp. 79. (Kantik Press, Calcutta.) Price, As. 10.

This little book written in popular Bengali is a commendable attempt on the part of an officer of the Bengal Department of Agriculture to make known its numerous activities in the form of four fascinating stories. Its perusal will dispel many doubts about the soundness of the propaganda work carried on by the department. The problem of unemployment is indirectly touched upon and the dignity of labour has been emphasized. The author finds little difficulty in demonstrating that agriculture conducted on scientific lines is a remunerative industry and can be pursued with profit by many men of the *bhadralok* class for whom the struggle for existence has become keener than ever. As observed by Sir P. C. Ray in the preface, the author has adopted the right method of arousing enthusiasm for improved methods of agriculture.

NEW BOOKS

On Agriculture and Allied Subjects

1. Crop-production in India, by Albert Howard, C.I.E. (Oxford University Press.) Price, 10*s.* 6*d.*
2. Oats : Their Varieties and Characteristics. A Practical Handbook for Farmers, Seedsmen and Students. Pp. 131. (London : Ernest Benn & Co.) Price, 8*s.* 6*d.*
3. Crops and Fruits, by J. R. A. Davis. The Resources of the Empire Series. Pp. 144. (London : Ernest Benn & Co.) Price 21*s.*
4. Manures and Fertilizers, by W. Dyke. Edited by T. W. Sanders. Pp. 142. (London : Collingridge & Co.) Price, 4*s.*
5. Chemistry in the Twentieth Century. An account of the Achievement and the Present State of Knowledge in Chemical Science. Prepared under the guidance of a committee representing the scientific societies, with Dr.E. F. Armstrong, F.R.S., as Chairman and Editor. Pp. 281. (London : Benn Bros.) Price, 15*s.*
6. The Punjab Peasant in Prosperity and Debt, by M. L. Darling, I.C.S. (Oxford University Press.) Price, Rs. 9.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs

1. Studies in Diseases of the Jute Plant. (2) *Macrophoma Corchori* Saw., by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S. (Botanical Series, Vol. XIII, No. 6.) Price, As. 8 or 9*d.*
2. Buffer Action of Some Burma Soils, by J. Charlton, M.Sc. (Chemical Series, Vol. VII, No. 5.) Price, As. 12 or 1*s.*
3. Studies in the Chemistry of Sugarcane, II. Some Factors that determine the Ripeness of Sugarcane, by B. Viswanath, F.I.C., and S. Kashinatha Ayyar, B.A. (Chemical Series, Vol. VII, No. 6.) Price, As. 8 or 9*d.*

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1. The *Agricultural Journal of India.* A Journal dealing with subjects connected with agricultural economics, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements, and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, and is issued once every two months or six times a year. *Annual Subscription,* Rs. 6 or 9*s.* 6*d.*, including postage. Single copy, R. 1-8 or 2*s.*
2. Scientific Reports of the Agricultural Research Institute, Pusa.
3. Annual Review of Agricultural Operations in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India.
   - (*a*) Botanical Series.
   - (*b*) Chemical Series.
   - (*c*) Entomological Series.
   - (*d*) Bacteriological Series.
   - (*e*) Veterinary Series.
7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Indigo Publications.
9. Books.

The following are the publications of the last two years :—

Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert and Secretary, Sugar Bureau), for the year 1922-23. Price, R. 1.

Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, the Physiological Chemist, and Secretary, Sugar Bureau), for the year 1923-24. Price, R. 1 or 1*s.* 8*d.*

Review of Agricultural Operations in India, 1921-22. Price, R. 1-4.

Review of Agricultural Operations in India, 1922-23. Price, R. 1-10.

Proceedings of the Board of Agriculture in India, held at Bangalore on 21st January, 1924, and following days (with appendices). Price, R. 1.

Proceedings of the Cattle Conference, held at Bangalore on 22nd and 23rd January, 1924 (with appendices). Price, As. 9.

Report of the Proceedings of the Fifth Entomological Meeting, held at Pusa, 5th to 10th February, 1923. Price, Rs. 9-8.

Proceedings of the Second Meeting of Veterinary Officers in India, held at Calcutta from 26th February to 2nd March, 1923 (with appendices). Price, R. 1-12.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA.

Botanical Series.

Vol. XII, No. II. I—History of the operations against Bud-Rot of Palms in South India. II—Inoculation Experiments with *Phytophthora palmivora* Butl. on *Borassus flabellifer* Linn. and *Cocos nucifera* Linn., by W. McRae, M.A., B.Sc. Price, R. 1-4 or 2*s.*

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Vol. XIII, No. II. The Wilt Disease of Safflower, by S. D. Joshi, B.Sc. Price, R. 1 or 1*s.* 6*d.*

Vol. XIII, No. III. Studies in Indian Fibre Plants. No. 3. On the Inheritance of Characters in *Hibiscus Sabdariffa* L., by Albert Howard, C.I.E., and Gabrielle L. C. Howard, M.A. Price, Rs. 2 or 3*s.*

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Vol. XIII, No. V. The Eradication of *Cyperus rotundus* L. : A Study in Pure and Applied Botany, by S. B. Ranade, B.Sc., and arranged and written by W. Burns, D.Sc. (*In the press.*)

Vol. XIII, No. VI. Studies in Diseases of the Jute Plant. (2) *Macrophoma Corchori* Saw., by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S. Price, As. 8 or 9*d.*

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